Research Study 69-4

STUDY OF IMAGE INTERPRETER USE OF AIDS AND EQUIPMENT

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BEHAVIORAL SCIENCE RESEARCH LABORATORY

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(6) STUDY OF IMAGE INTERPRETER USE OF AIDS AND EQUIPMENT

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FOREWORD

The SURVEILLANCE SYSTEMS research program has as its objective the development of scientific data bearing on the extraction of information from imagery obtained through aerial reconnaissance and the efficient storage, retrieval, and transmission of information within an advanced computerized image interpretation facility. Human Factors research on techniques for improving the output of such systems is conducted under Army RDT&E Project 2Q620901A721, "Surveillance Systems: Ground Surveillance and Target Acquisition Interpreter Techniques," FY 1969 Work Program.

Among the concerns of the Work Unit, "Influence of DISPLAYS on Image Interpreter Performance," is the need to develop information on procedures and equipment used to maintain and improve system personnel proficiency, information flow, and duty station assignment for near real-time and infrared image interpretation, as well as for the interpretation of more conventional imagery.

BESRL research in this area is conducted as an in-house effort augmented by contracts with organizations selected as having unique capabilities and facilities for research in aerial surveillance. The present study, dealing with interpreter use of aids and equipment, was conducted jointly by personnel of the Advanced Systems Division, System Development Corporation, and of the Behavioral Science Research Laboratory.

J. E. UHLANER, Director
U. S. Army Behavioral Science
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STUDY OF IMAGE INTERPRETER USE OF AIDS AND EQUIPMENT

BRIEF

Requirement:

To evaluate the usefulness of tools and equipment furnished interpreters, and, in particular, to determine what equipment should be included in kits for personal issue to interpreters.

Procedure:

Analysis was made of the tasks performed in interpreting photographic imagery. Task elements were defined with emphasis on determining what tools and aids are used--or needed--by interpreters in completing each element. Interpreter assignments were examined to determine whether any amount of interpreter activities is done under conditions where the interpreter has to depend wholly on the equipment in his kit.

Findings:

1. While all items now included in the P. I. kit are used by the interpreter at one time or another, some of the items are rarely used.

2. The P. I. kit as now constituted does not provide complete interpretation capability but must be supplemented by section supplies and reference materials.

3. Contents were selected for an abbreviated kit which would equip the interpreter with the tools and devices he uses most often--tube magnifiers, stereoscope, P. I. slide rule, and P. I. scale. All other needed items can be drawn from supplies maintained by the facility.

4. The need for additional aids for mensuration and plotting was revealed. Tube magnifier reticles for measuring small objects, and plotting templates for use with panoramic camera systems were devised.

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Utilization of Findings:

It has been recommended that the abbreviated kit be made available for personal issue.

It was also recommended that the mensuration and plotting aids developed in the study be constructed and distributed for operational use in image interpretation facilities.

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STUDY OF IMAGE INTERPRETER USE OF AIDS AND EQUIPMENT

OBJECTIVE

Each image interpreter in the Army is supplied with a kit of aids and equipment for use in performing his assigned tasks. Since World War II, four generations of the Photointerpreter (P.I.) kit have been in use. The first came into service about 1947. This unit was known as Interpretation Kit, Photographic, F-3 (Federal Stock Number FSN 6675-641-3606). The second kit was introduced some time in 1959 by the Army Engineer Corps. The two kits presumably differed only in the color and construction of the case. Up to that time, no specifications for the item existed. By 1963, specifications had been developed and the two earlier models were deemed obsolete. In quick succession, a third and fourth version appeared. Although the third version has been issued to the troops, it was found to be not entirely responsive to the specifications [MIL-1-52295 (MO)], and the fourth version was authorized as a replacement. The latter P.I. Kit (FSN 6675-202-8542) is still issued to units.

The kit now in service includes magnifiers, stereo viewers, measuring scales of several kinds, a slide rule, and other items. With the development of advanced techniques for obtaining and displaying aerial imagery, there was need to review the aids routinely furnished the interpreter for adequacy for current operations. The U. S. Army Assistant Chief of Staff for Intelligence (ACSI) directed that such a review be conducted.

The present evaluation was concerned with the contents of the Photointerpreter Kit as used in the interpretation of photographic imagery, including both optically and electronically reproduced transparencies or prints. Other materials used to detect, identify, and prepare for dissemination the intelligence information contained in photographic imagery were also considered. The special case of interpretation directly from cathode ray tubes or media other than transparencies or prints requires separate study.

In view of the foregoing, the term "photointerpretation" seems appropriate for the task here considered. When the newer and more exotic display systems have been perfected and their peculiar equipment requirements established and provided for, the generic term "image interpretation" would perhaps be more accurate.

TASK ANALYSIS

The first step was to prepare a detailed task analysis of image interpreter activities, describing the specific elements of each task and indicating the tools and aids required for each task element. This analysis (Appendix A) was prepared under direction of the author by

personnel of the U. S. Army Behavioral Science Research Laboratory.[1] Four experienced image interpreters employed at BESRL examined the original draft of the task analysis to assure that all elements and associated tools and aids were included.

The detailed task analysis was then taken to Fort Holabird, Maryland, where over 40 experienced image interpreters at the U. S. Army Intelligence School and Image Interpretation Center reviewed the document. These interpreters had been in the Army from 3 to 21 years and had had up to 8 years' experience in imagery interpretation (average: 4 to 5 years). The comments obtained from this review brought out the fact that NATO Standard Agreements (STANAG) and the DOD conference on Imagery Interpretation Report Formats (31 July - 4 August, 1967) had established requirements for somewhat different report formats than those discussed in the task analysis. Although operational report formats may have changed somewhat since the analysis was completed, the photo imagery interpretation task would remain essentially the same, as would the tools and aids needed for these activities.

WHERE IMAGE INTERPRETATION IS PERFORMED

Facilities which house present-day imagery interpretation teams are of several varieties. One type, the AN/TSQ-43, of which more than a score have been constructed, is designed to accommodate a normal shift complement of 5 interpreters. This facility can be collapsed into a compact van (Type M4) for transportation by the 5-ton chassis truck (Type M46) on which it is mounted. The AN/TSQ-43, an interim Tactical Imagery Interpretation Facility (TIIF), is typically deployed in the Vietnam theater of operations. In addition to 5 P. I. Kits of current issue, each AN/TSQ-43 contains:

2 Viewers (light tables), Stereoscopic Roll Film, Photographic Interpretation AR-90A

1 Console, Viewer-Computer, Imagery Interpretation, AR-85A

1 Viewer (Variable Power Stereoscopic), Stereoscopic Roll Film, Photographic Interpretation, AR-91A

2 Plotting Tables, Photographic Film AR-87A

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[1] Special acknowledgement is made to Mr. Arthur J. Lynch, who provided most of the initial detailed descriptions of the tasks. Mr. Lynch, a former Army image interpreter with more than 10 years' experience in this field, is employed by North American Rockwell Corporation, one of several BESRL contractors.

Stereoscope (Zoom 95), Lens-Prism-Mirror, Aerial Photographic Interpretation, AR-06A

Stereoscope (Zoom 70), Lens-Prism-Mirror, Aerial Photographic Interpretation, AR-97A

Magnifier (Macroscope), Photographic, Variable Power

Communications equipment in the form of teletype and telephones are also provided.

A future generation of this type of facility calls for telemetry receivers, film processors and projectors, and an interface with other ground terminal stations. Moreover, the mobile TIIF of the future, designed to move with the specific organization it services, will be an integral part of the G2 communications net. It will contain input/output devices compatible with the digital data transmission equipment of the intelligence subsystem of the command/control information system. The equipment of the mobile TIIF and its antecedent AN/TSQ-43 is constructed to work primarily with transparencies.

Other facilities used at present, and in recent years in Korea and European areas, include mobile and air transportable units such as an expansible van (M-292) and a 2-wheel, 6-ton semi-trailer cargo van (M-119), as well as non-permanent structures such as Quonset huts and tents. In these installations, light tables and 35" x 35" lithographic layout tables with fluorescent backlighting are generally used to select negative frames for print reproduction. At some locations, prints are still almost exclusively used for interpretation, and negatives on the roll are used mostly for making map overlays of area coverage.

Image interpretation sections in all these facilities may be required to perform any or all the tasks defined by the task analysis. However, the limited space in a TIIF such as the AN/TSQ-43 may curtail some activities, for example, the size of uncontrolled mosaics.

Image interpreters almost always work in an environment designed specifically for image interpretation and related activities--be it a movable or transportable van or a temporary shelter such as a tent--according to a number of experienced interpreters interviewed. In fact, the unanimous opinion was that the situation where the interpreter works as a one-man unit within another type of Army activity does not occur.

OPERATIONAL ACTIVITIES--PHOTOGRAPHIC IMAGERY INTERPRETATION

The following brief overview indicates the coverage of the task analysis and the activities involved in interpretation of photographic, infrared (IR), and Side-Looking Airborne Radar (SLAR). The tasks considered entailed the use of imagery which appears as prints or transparencies. Activities in real-time or near real-time interpretation were not investigated in the present study.

Interpretation of optically derived photographic imagery involves preparation of the following reports:

Photographic Plots. Areas covered by each photograph are outlined on a map overlay of tracing paper.

Master Cover Trace. This acetate map overlay is the final result of plotting and represents the set of pertinent imagery plots which relate to a given area.

Hot Report. This type of report results from specific requests for information relating to the purpose of a given photographic mission. It is also generated when new developments, crucial to current operations, are discovered during interpretation. Hot Reports are transmitted by the most rapid means of communication available (usually teletype or telephone).

Immediate Report. This short written report supplements, corrects, or replaces a Hot Report.

Mission Review Report. This report provides intelligence agencies with items of intelligence extracted from an imagery mission. It enables the using agency to select only that coverage needed to fulfill its specific requirement.

Detailed Report. This type of report is oriented towards a comprehensive account of any one of a wide variety of subjects.

Summary Report. Concerning itself with a particular subject category, the summary report is time-period and area oriented. Mission Review Reports normally provide the source material for the Summary Report.

Special Report. This class of report is used to meet special requirements not covered by the foregoing reports. Examples of special reports are as follows:

Defense Overlay--A map overlay showing concentration, disposition, and movement of enemy troops as well as location and identity of enemy installations (major weapons, communications, and defense facilities).

Road and Bridge Study--Results in a map overlay showing the road network and location of bridges found in photographs.

Trafficability Study--End product is a map overlay showing locations where terrain is passable, difficult of passage, or impossible of passage for wheeled vehicles.

Uncontrolled Mosaic--An arrangement of opaque prints into a large composite photograph of a given area.

Drop Zone Study--A detailed study of photos of an area previously selected by higher headquarters to determine its suitability as a drop zone for troops or equipment.

Target Folder Preparation--A compilation of information obtained from all available sources on a specific point, area, object, or group of objects at which fire can be directed. Normally, the image interpreter is concerned only with the Target Illustration Sheet and part of the Target Information Sheet which form part of the Target Folder.

OPERATIONAL ACTIVITIES--INFRARED IMAGERY INTERPRETATION

The following result from interpretation of photographs derived from electronic data obtained through infrared sensors:

Photographic Plots: A map overlay of tracing paper, outlining the areas of infrared imagery coverage.

Master Cover Trace. The Master Cover Trace for infrared imagery is an acetate map overlay. As with conventional photo imagery, it is the final result of plotting and represents the set of infrared imagery plots relating to a given area.

Hot Report. A Hot Report on IR imagery is handled in a manner similar to that of conventional photo-imagery--as a response to specific requests for information concerning the area covered and to report on detected items of information which may be critical to current operations. However, there are two exceptions to the manner in which IR imagery is interpreted: 1) The imagery is scanned quickly to detect heat emitters and absorbers so that man-made objects can be identified on the basis of size, shape, shadow, shade, surroundings, and signal strength; and 2) if the sensor produces stereo imagery, an appropriate viewing device is used to take advantage of the third dimensional aspect as an aid in identifying detected objects.

Immediate Report. This written report supplements or replaces a Hot Report.

Additional Reports. Normally, the Immediate Report is the last report made on IR imagery. However, the Immediate Report may be used as a source of information to be included in a Summary, Detailed, or Special Report.

OPERATIONAL ACTIVITIES--SIDE-LOOKING AIRBORNE RADAR (SLAR) IMAGERY INTERPRETATION

Interpretation of photographs derived from electronic data obtained through radar sensors involve preparation of the following:

Photographic Plots. A map overlay of tracing paper outlining the areas of SLAR coverage.

Master Cover Trace. This acetate map overlay is the final result of plotting and represents the set of pertinent imagery plots which relate to a given area and usually for a given period of time.

Hot Report. As with the Hot Reports for conventional photo imagery and IR imagery, SLAR Hot Reports respond to specific requests for information or are generated because detected objects may have an important bearing on current operations. Two techniques in the interpretation of SLAR imagery differentiate it from interpretation of conventional photo imagery: 1) The imagery is scanned quickly to detect man-made objects on the basis of size, shape, shade, surroundings, and signal strength, including detection of moving objects by their "blips" on the MTI presentation of the imagery; and 2) measurement of certain objects requires the addition of one beamwidth to the total dimension of the object or its subtraction from that dimension.

Additional Reports. Normally, the Hot Report is the only report made on SLAR imagery. The Hot Report, however, may be used as a source of additional information for inclusion in a Summary, Detailed, or Special Report.

INTERPRETER USE OF AIDS AND EQUIPMENT

The tasks performed by the photointerpreter require use of aids and equipment of the general types described below. Figure 1 indicates the tasks and the specific kinds of equipment the interpreter uses to complete the task.

Magnifiers. Among the optical aids used in photointerpretation are tube magnifiers--monocular, manually manipulated devices which are manufactured in a range of powers of magnification. Typically, the powers are: 2X, 7X, 8X, and 12X. The lower power magnifiers permit larger area coverage than do the higher power magnifiers. The lower power devices are therefore often used for rapid screening of imagery for target detection. For more general use in interpretation of detected targets, a magnification level in the mid-range has been found to be most satisfactory. A 7X tube magnifier, for example, permits a substantial degree of magnification which is still below the point of optical disintegration for the photographic imagery in general use in present-day military systems. Magnification with the 7X device still permits presentation of sufficient area surrounding most objects of interest to enhance object identification. In other cases, where the quality of the print or transparency permits and when the imaged object is quite small, a tube maginfier of even higher magnification is required. A special form of this type of instrument is a zoom macroscope. One model of macroscope presently available can provide selectable and continuous magnification from 10X to 30X.

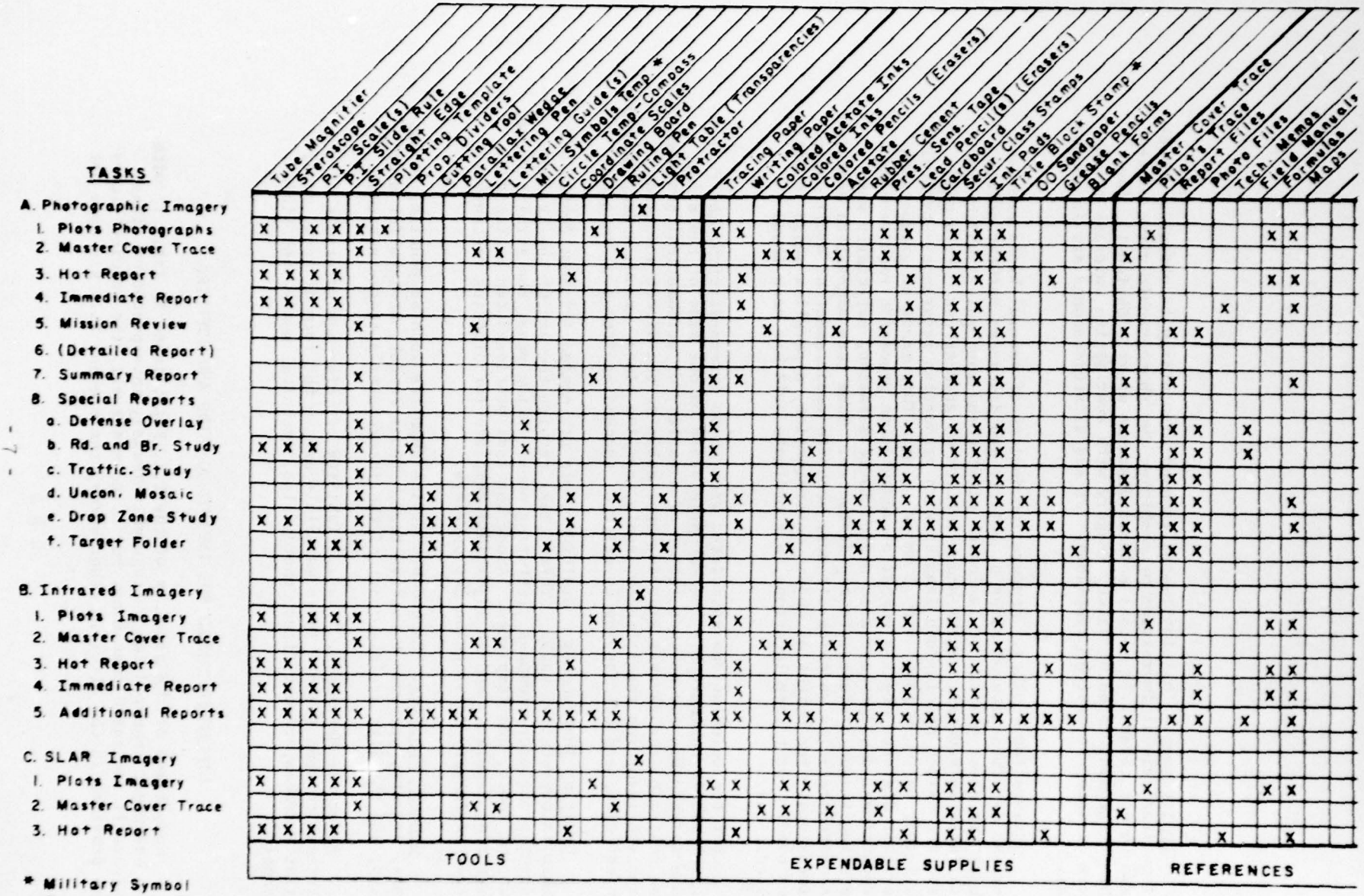

Figure 1. Summary Sheet of Tools and Aids Required for Image Interpretation Tasks

Stereoscope. This instrument is used binocularly to obtain a three-dimensional visual impression by combining two photographic views of the same object taken from points a short distance apart. Obviously, for this instrument to be of value, imagery with overlapping coverage of the area of interest must be available. 2X and 4X stereoscopes are in common use.

Mensuration Devices. Mensuration devices of several kinds are used for the determination of sizes of objects and distances between points. These are clear plastic or laminated plastic and wood rulers which are available in several lengths and a variety of graduations. Frequently used are 6-inch and 12-inch lengths with graduation references--typically, .001 foot or .0005 foot, and .1 mm or .5 mm. This range of graduations per unit distance meets a number of mensuration precision requirements. Proportional dividers are also useful in mensuration, especially when relating imaged distances to map distances. Some tube magnifiers contain graduated reticles which permit more accurate measurement of small object dimensions. For height of object determination, a parallax wedge is often employed. For target locations, a coordinate grid has been found expeditious.

For the calculations associated with photo interpretation, the P. I. slide rule is convenient. The Mannheim scale on one side of the slide rule is valuable for quick solution of a variety of arithmetical problems. The scales on the reverse side are applicable to the direct solution of problems involving focal length, scale, cycling times, ground speed, imaged object size, and overlapping coverage of succeeding frames of imagery.

Drafting Instruments. Drafting tools are needed for some phases of photo interpretation tasks. These tasks require the use of the drawing board, protractor, compass, lettering pens, ruling pens, the straight edge, cutting tools, and templates. Among the last mentioned can be found lettering templates and an adjustable template for plotting rectangular areas of imagery coverage on map overlays.

General Supplies. Expendable office supplies such as pencils, paper, inks, erasers, pressure sensitive tape, rubber cement, acetate for overlays, and the like are also part of the interpreter's stock-in-trade.

Reference Materials. The availability of reference materials is critical to some tasks. These materials are in the form of keys, maps, pilot's traces, report files, photo files, technical memos, and field manuals.

INTERPRETER NEED FOR INDIVIDUAL AIDS AND SUPPLIES

Comparison of the contents of the P.I. Kit (listed in Table 1) with the equipment required for photographic imagery interpretation tasks (Figure 1) indicated that many, but by no means all, the required items are provided in the Kit. In other words, the present P.I. Kit does not

provide complete photo interpretation capability. The following items, used by interpreters and usually available as section supplies, are not included in the Kit:

Tools and aids. Drawing board, light table.

Expendable supplies. Tracing paper, writing paper, colored acetate inks, colored inks (except India ink), colored pencils, acetate, cardboard, security classification stamps, ink pads, pressure sensitive tape (masking tape), 00 sandpaper, blank forms.

Reference materials. Maps, pilot's trace file, report files, photo files, technical memos, field manuals, master cover trace file.

The point at issue was whether the individual interpreter needs to maintain in his personal kit all the materials needed for complete interpretation capability.

The task analysis revealed that certain items in the kit are used regularly by interpreters, whereas others are seldom taken out of the kit. All items in the kit are used at one time or another.

In some facilities, kits are almost never opened, since almost all expendables are available from a central supply. In some other facilities, expendables may be removed from individual P.I. kits and added to the central supply of the section. In that case, the P.I. kit in effect ceases to exist. Since imagery interpretation is almost exclusively performed in a facility housing an organizational image interpretation section with an adequate central supply, the issuance of many items constituting the kit to individual interpreters seems unwarranted. Even if a situation should arise where an interpreter is required temporarily to perform his tasks away from a facility, the materials in the P.I. Kit alone would not permit full capability. Additional aids and supplies would be needed such as a light table and reference documents. If the temporary duty entails only specific activities such as issuing Hot and/or Immediate Reports from prints, then only a relatively few selected items would be needed from the kit, in addition to some reference materials.

It therefore seems practicable--and advisable as a work simplification procedure--to reduce the P.I. Kit to the few items the interpreter uses most often. The abbreviated kit would contain the following items:

Tube magnifier, 7X (with changeable reticles)

Stereoscope, 2X or 4X or combination

P.I. slide rule

P.I. scale

Table 1

COMPONENTS OF INTERPRETATION KIT, PHOTOGRAPHIC, ARMY TYPE
(FSN 6675-202-8542)

Components	Quantity
Adhesive, rubber, artists'	1
Accessory box, photographic, plastic	1
Case, carrying, photographic interpretation kit	1
Clips, paper	1 box
Compass, drafting, friction, pivot: with case	1
Compass, drafting, pivot, 4 to 5 inches long	1
Dividers, drafting, proportional	1
Eraser, rubber; combination ink and pencil	2
Eraser, rubber; art gum	2
Height finder, parallax wedge	1
Ink, drawing, black; waterproof	1
Lead, pencil, graphite; for draftsmen's mechanical pencils	3 pkg
Lead, pencil, colored; for glass-surface marking; 0.120-inch diameter, 2 3/4-inch long	3 box
Line guide, lettering, nonadjustable	1
Magnifier: monocular; 7 power	1
Magnifier: monocular; reading, with case	1
Padlock and chain	1
Pencil, mechanical: clutch action; for artist's and drafting leads 0.070- to 0.076- inch diameter	3
Penholder, crowquill; wood	2
Penholder, writing; wood	1
Penpoint; crowquill	12
Penpoint assortment; lettering	1
Plotting template; adjustable	1
Protractor, semicircular; plastic	1
Scale, drafting, engineer's	1
Scale, drafting; photo interpreter's	1
Sharpener, pencil	1
Shears	1
Slide rule, aerial photo; with manual	1
Stereoscope, 2 power	1
Stereoscope, 4 power	1
Tape, gummed; mending and reinforcing, (paper and cloth)	1
Thumbtacks	1 box
Triangle, drafting	1
T-square	1

SUGGESTED ADDITIONAL AIDS

During the study, it became evident that there were some aids which would be useful in image interpretation work if they were made available. An item which is not included in the P.I. Kit or section supplies but which finds widespread use among interpreters is a fountain pen designed to work with drawing ink. Such pens are available with a variety of point sizes for making different width lines and are used in preference to the points and crowquill pens provided in the kit. Since such points may find occasional use, a set or two should be retained as section equipment. But many interpreters prefer the fountain-type pen for more general use and now purchase their own pens.

An item not available but which would be a great convenience and should be developed is a pocket-sized plastic coated or laminated card containing the most often used mensuration, scaling, and area coverage formulas. A ready reference of this kind would save time spent in searching out the desired formulas from several different sources.

Military symbol templates to be used in making defense overlays would be convenient time savers and would also serve to promote standardization in symbol size and form. A few resourceful interpreters have constructed their own symbol templates from flat plastic material.

In a pilot study of variability of imagery interpreter performance in measuring image size completed by the author prior to the present study, it was found that the use of rulers and reticles referenced to thousandths of a foot as compared to millimeters made little difference in mensuration variability. This finding would seem to indicate that, unless there is reason to do otherwise, mensuration scales in only one metric system need be provided in photo interpretation work. The study also showed that measurements of small objects obtained through the use of reticles in tube magnifiers are less variable from one interpreter to another than those obtained through use of rulers and separate tube magnifiers. The latter finding led to a more detailed study of reticles and how they are used. This effort resulted in several reticle designs for tube magnifiers which should make for easier and more accurate mensuration of small objects. Appendix B contains a description of these reticles as well as a discussion of some of the problems in mensuration they are designed to overcome.

A plotting template for use in making plots of imaged area coverage on map overlays is included in the present P.I. Kit. This tool has great utility for plotting areas of coverage provided by conventional vertical photographs. However, templates for making plots of panoramic camera area coverage where the shape of the plots is unusual and extremely difficult to define have not existed until now. Five plotting templates for use with the KA-55, KA-56, and KA-60 panoramic camera systems have been designed and constructed during this study. These templates, their construction, and use are described in Appendix C. A brief plotting

exercise using 16 recent graduates from the U. S. Army Intelligence School at Fort Holabird, Maryland, was conducted (See Appendix D for the detailed results of this exercise). In a balanced experimental design utilizing KA-55 Hi-Pan and KA-56 Low-Pan vertical imagery, each image interpreter was given the task of plotting a frame of imagery from one camera system freehand and a frame from the other camera system using the appropriate template. Aside from the variety of shapes and sizes the freehand plots produced, the freehand plots, on the average, took twice as long as the template method to make with the KA-55 imagery and 3.6 times as long with the KA-56 imagery. Unfortunately, imagery for the KA-60 forward oblique panoramic camera system with associated 1:50,000 scale maps could not be located in the short time available for this phase of the study. It is anticipated, however, that the time saved in plotting this kind of area coverage will be considerable.

APPENDIX A. IMAGERY INTERPRETATION TASK ANALYSIS

TASK ELEMENT	TOOLS AND AIDS REQUIRED
A. Photographic Imagery Interpretation (transparencies or prints)	Light table required for transparencies
1. Plots photographs. Outlines area covered by each photograph on a map overlay utilizing a plotting template. Normally, photo plots are made on 1:250,000 map base.	
a. Determines proper map sheet on which to plot the photographs by referring to pilot's trace, or from identifying data on photograph, or by inspection (relying on interpreter's familiarity with area imaged).	Maps; pilot's trace
b. Places sheet of tracing paper over map and fastens to drawing board.	Tracing paper; masking tape; drawing board
c. Registers overlay by drawing in intersecting grid lines in two diagonal corners of the overlay.	Lead pencil, straight edge
d. Prints in title block.	Lead pencil
e. Determines scale of photographs by one of the following methods:	Pencil and paper or P. I. slide rule
(1) Reads scale from marginal data.	
(2) Uses ratio of focal length of lens to altitude of camera platform.	
(3) Measures the distance between two or more identifiable points on the photograph and the distance between the same points on the map.	Tube magnifier; P. I. Scale; pencil and paper or P. I. slide rule

TASK ELEMENT	TOOLS AND AIDS REQUIRED
(4) Measures an object of known dimension on the photograph and divides this distance into the actual dimension of the object.	Tube magnifier; P. I. Scale; pencil and paper or P. I. slide rule
f. Adjusts plotting template to proper size using the formula: Scale of photo multiplied by size of photo divided by scale of map, computing separate length and width settings if image area is rectangular.	Plotting template; P. I. slide rule or pencil and paper
g. Locates area covered by photograph on map by inspection, using two or more known points at top and bottom or sides of photograph.	
h. Places plotting template over proper area on map and outlines the area on the overlay.	Lead pencil
i. Numbers outlined area with serial number of photo.	Lead pencil
j. Plots remainder of photos of sortie as detailed above.	
k. Stamps appropriate security classification at top and bottom of overlay.	Security classification stamps; ink pad
2. Master Cover Trace. The Master Cover Trace is the final step in plotting and is a collation of all the imagery received. It also serves as an index to available imagery and is usually on acetate or overlay paper. Imagery is usually plotted to a common scale base map, so that the cover trace can be posted directly from the photo plot.	
a. Folds back cover trace overlay from base map.	
b. Orients photo plot to base map utilizing intersecting grid lines for registration; affixes plot to base map.	Masking tape

TASK ELEMENT	TOOLS AND AIDS REQUIRED
c. Returns cover trace overlay to former position so that it overlays both the base map and the sortie plot.	
d. Traces the outline of the entire area covered by the photo plot. Traces each plot in different colored ink so that overlapping missions are discernable.	Ruling pen; acetate; colored acetate inks (3 or 4); straight edge
e. Enters mission number and flying organization (normally in the lower left-hand corner of the outline).	Lettering pen and ink
f. Makes necessary entries in title block.	Lettering pen and ink; lettering template set
g. Stamps appropriate security classification on top and bottom of each page.	Security classification stamp; ink pad
3. Hot Report. This report is rendered at the earliest possible time after the imagery is interpreted. It provides information in response to the specific purpose for which the mission was flown, or reports any new developments vital to current operations. The report is disseminated to concerned elements by the most rapid means of communication available.	
a. Scans photos quickly to detect man-made objects on the basis of size, shape, shadow, tone, and relationship to surrounding objects.	Tube magnifier; stereoscope
b. Indicates by checkmark on photograph any objects of interest for the report.	Grease pencil
c. Examines selected overlapping stereo pairs in third dimensional aspect utilizing a stereoscope to aid in the identification of detected objects.	Stereoscope (Some split-vertical and high and low panoramic transparencies require a viewer with optical image rotating capability.)

TASK ELEMENT	TOOL AND AIDS REQUIRED
d. Measures length and width of objects using interpreter's scale or tube magnifiers with mensuration reticles to assist in identification and to determine approximate scale of imagery.	Tube magifier; P. I. Scale; pencil and paper or P. I. slide rule
e. Determines coordinates of identified items by locating their position on the map and reading the coordinates utilizing the appropriate coordinate scale.	Map; coordinate scales; proportional dividers
f. Makes written list of items detected and identified on the mission and coordinates of each.	Pencil and paper
g. Stamps appropriate security classification at top and bottom of each page.	Security classification stamps; ink pad
h. Gives written record to OIC or NCOIC for typing and dissemination to concerned units.	
4. Immediate Report. An Immediate Report is a short written report produced in addition to, or in lieu of, a Hot Report; it may contain one or more subjects depending upon the content of the imagery.	
a. Repeats all steps listed in paragraph 3, above.	
b. Additionally, detects and identifies every item of military significance on the imagery. Refers to appropriate interpretation keys as an aid to interpretation.[1]	Tube magnifier; P. I. scale; pencil and paper or P. I. slide rule; maps; P. I. Keys; stereoscope(s)

[1] The following list of P. I. Keys should be available for ready reference by the interpreter. The particular key required for a given task depends on the physical characteristics of the imaged object (truck, tank, APC, missiles, etc.)

TM	30-246	30-252	30-257	30-264	30-270	30-274	30-279	30-283
	30-248	30-253	30-258	30-265	30-271	30-275	30-280	30-284
	30-249	30-254	30-262	30-268	30-272	30-277	30-281	30-285
		30-256	30-263	30-269	30-273	30-278	30-282	30-286

Regional keys showing such local items as geography, architecture, and industries are also required; in addition, locally prepared keys are often utilized.

TASK ELEMENT	TOOLS AND AIDS REQUIRED
c. Stamps appropriate security classification at top and bottom of each page.	Security classification stamp; ink pad
5. Mission Review Report. The Mission Review Report provides intelligence agencies with a resume of the intelligence items covered on an imagery mission. It enables the using agency to select only that coverage needed to fulfill its specific requirement.	
a. Places sheet of clear acetate over photo plot, then traces the plot and register marks in ink, tracing only those prints which indicate change in direction of the flight line.	Acetate; ruling pen; India ink; straight edge
b. Removes acetate from photo plot.	
c. Orients acetate overlay to appropriate map base and affixes it.	Masking tape
d. Applies or draws title block on overlay and inserts appropriate data.	Title block forms or ruling pen; ink; straight edge; lettering pen
e. Stamps or draws appropriate security classification at top and bottom of overlay.	Security classification stamp; ink pad
f. Sends overlay still attached to map base to reproduction section for reproduction.	
g. Normally, the interpreter can extract sufficient information from previously published reports (Hot and Immediate Reports) to satisfy the requirements of the written portion of the report. However, on certain types of targets, he may have to reinterpret the imagery (as in pars. 3 and 4) to get sufficient detail to satisfy requirements.	
h. Prepares written portion of the report.	

TASK ELEMENT	TOOLS AND AIDS REQUIRED
i. Gives written portion of the report to OIC or NCOIC.	

6. Detailed Report. There are so many uses for Detailed Reports and they may be prepared on so many different subjects that it is somewhat difficult to explain them in general terms. The characteristic feature of detailed reports is that they almost invariably deal with one particular subject. No meaningful task analysis can be made of this report type because each report tends to be unique.

NOTE: Analysis is based upon types of reports in use 1 July 1967. NATO standard agreements (STANAG) and the DoD conference on Imagery Interpretation Report Formats: 31 July-4 August 1967, indicate a requirement for formats which are somewhat different. However, the image interpretation tasks would remain essentially the same using existing source documents plus two additional source documents. The latter two additional documents, Bombing Encyclopedia and Functional Category Code, are new to the Army image interpreter.

7. Summary Report. A Summary Report records coverage of installations or activities within any one particular subject category falling within a given area during a specified time period. The source material for Summary Reports is normally Mission Review Reports.

a. Refers to Summary Report to determine most recent report on the area of concern.	Summary Report File
b. Removes most recent Summary Report from file.	

TASK ELEMENT	TOOLS AND AIDS REQUIRED
c. Screens Mission Review Report File to determine which missions covered the area of concern since last Summary Report	Mission Review Report File
d. Removes applicable Mission Review Report(s) from file.	
e. Extracts information from Mission Review Report(s) pertaining to subject area.	
f. Checks information against reports to determine developments or trends of activity in the area of concern.	
g. Prepares written portion of report.	Paper and pencil
h. Stamps appropriate security classification at top and bottom of each page.	Security classification stamp; ink pad
i. Selects map(s) that cover the target.	Maps
j. Fastens map(s) to drawing board.	Drawing board
k. Affixes sheet of tracing paper to map.	Tracing paper; masking tape
l. Registers overlay by drawing intersecting grid lines in two diagonal corners of the overlay.	Lead pencil; straight edge
m. Draws or stamps title on overlay and makes appropriate entries therein.	Lead pencil; straight edge or title block stamp and ink pad.
n. Draws in sufficient detail on overlay to accurately depict changes in the target which have occurred subsequent to the last Summary Report.	Lead pencil; straight edge
o. Stamps appropriate security classification at top and bottom of each page.	Security classification stamp; ink pad

TASK ELEMENT	TOOLS AND AIDS REQUIRED
8. <u>Special Report</u>. The Special Report is used to meet requirements for a special presentation of subject matter that cannot be adequately met by other types of report. The most common types of Special Report and their methods of presentation are as follows:	
a. Defense Overlay--Determines disposition and movement of enemy troops, troop concentrations, location and identity of enemy installations, major weapons, communications, and defense facilities; presents them as a map overlay.	
(1) Places sheet of tracing paper over map and fastens to drawing board.	Tracing paper; masking tape
(2) Registers overlay by drawing intersecting grid lines in two diagonal corners of the overlay.	Lead pencil; straight edge
(3) Draws or stamps in title block.	Lead pencil; straight edge; title block stamp and ink pad
(4) Refers to Imagery Intelligence Report reference files and withdraws most recent reports covering the area of interest.	Imagery intelligence report files
(5) Extracts information from above reports and draws appropriate symbol at exact map location of each identified object, using standard military symbols. In the event improvised symbols are used, a key explaining their meaning must be included in the title block.	Lead pencil; Military Symbol Template (not provided now) Military Symbol Field Manual (FM 21-30)
(6) If the most recent imagery has not been reported on in sufficient detail to satisfy this requirement, interpreter selects appropriate photos from file and interprets imagery as outlined in pars. 3 and 4b, above.	Photo file

TASK ELEMENT	TOOLS AND AIDS REQUIRED
(7) Stamps appropriate security classification at top and bottom of overlay.	Security classification stamp; ink pad
b. Road and Bridge Study--Prepares road net overlay by tracing roads and bridges shown on map and by adding new roads and bridges found on photos to provide accurate information on roads in area of interest.	
(1) Places sheet of tracing paper over map and fastens map to drawing board.	Tracing paper; masking tape
(2) Registers overlay by drawing intersecting grid lines in two diagonal corners of the overlay.	Lead pencil; straight edge
(3) Prints or stamps in the title block.	Pencil; title block stamp; ink pad
(4) Traces road net shown on map.	Lead pencil; straight edge
(5) Refers to Master Cover Trace to select most recent coverage of area of interest.	Master Cover Trace
(6) Removes selected photos from file.	Photo file
(7) Compares roads shown on map with those on photos to determine whether photos include roads not shown on map and any changes in type, classification, and characteristics.	
(8) Sketches on overlay new roads found on photos, utilizing proportional dividers to insure accuracy.	Lead pencil; straight edge; proportional dividers
(9) Determines width of roads by measuring with interpreter's scale or tube magnifier.	Tube magnifier; P. I. scale

TASK ELEMENT		TOOLS AND AIDS REQUIRED
(10)	May color-code roads, using different colors to indicate the number of lanes of traffic each road can carry.	Colored pencils (3 or 4); straight edge
(11)	Determines type of surface of roads shown on photos by studying photos and comparing the tone and shade of road with the tone and shade of surrounding objects.	Some available magnifying device
(12)	Classifies roads by segment in accordance with formula detailed in FM 5-36.	Route Reconnaissance Field Manual (FM 5-36)
(13)	Indicates all bridges by drawing appropriate symbol on overlay.	Military Symbol Field Manual (FM 21-30); template
(14)	Determines length and width of bridges by measuring with interpreters scale or tube magnifier with mensuration reticle.	Tube magnifier; P. I. scale
(15)	Studies photo and/or stereo pairs to determine type of bridge and construction materials.	Tube magnifier; stereoscope
(16)	Assigns arbitrary number to each bridge and enters it beside the symbol.	Lead pencil
(17)	Indicates on overlay margin, by means of numbered outline sketches, the side elevation (includes abutments and supports), length, width, of each bridge and construction materials.	Lead pencil
(18)	Stamps appropriate security classification at top and bottom of overlay.	Security classification stamp; ink pad

TASK ELEMENT	TOOLS AND AIDS REQUIRED
c. Trafficability Study--Prepares map overlay indicating whether terrain is passable, difficult of passage, or impossible for wheeled vehicles.	
(1) Places sheet of tracing paper over map and fastens to drawing board.	Tracing paper; masking tape; drawing board
(2) Registers overlay by drawing intersecting grid lines in two diagonal corners of the overlay.	Lead pencil; straight edge
(3) Prints or stamps appropriate security classification at top and bottom of overlay.	Security classification stamp; ink pad
(4) Traces roads, railroads, streams, swamps, and wooded areas which appear on map.	Lead pencil; colored pencils; straight edge
(5) Refers to Master Cover Trace and determines most recent cover of area of interest.	Master Cover Trace
(6) Removes selected photos from photo file.	Photo file
(7) Studies photos to ascertain terrain condition not shown on map (such as soil type, roads made impassable by recent rains or which would become impassable during rainy weather).	
(8) Completes trafficability overlay by indicating areas which are passable, difficult of passage, or impassable for wheeled vehicles under varying weather conditions; utilizes color coding, crosshatching, and/or shading for each classification.	Colored pencils; lead pencils; straight edge
(9) Stamps or prints in title block and makes necessary entries thereon.	Colored pencil; title block stamp; ink pad

TASK ELEMENT	TOOLS AND AIDS REQUIRED
(10) Stamps appropriate security classification at top and bottom of overlay.	Security classification stamp; ink pad
d. Uncontrolled Mosaic (prints only)--An arrangement of separate photos of the mission(s) to provide one large composite photo of the area of interest.	
(1) Refers to Master Cover Trace to determine what mission(s) cover the area of interest.	Master Cover Trace
(2) Removes selected photos from print file.	Photo file
(3) Lays photos out in loose mosaic.	
(4) Checks loose mosaic against map to insure coverage of the area of interest.	Map
(5) Selects piece of flat material large enough to become a base of the mosaic. (Since different base materials require different adhesives and slightly different techniques of laying the mosaic, this analysis applies only to a mosaic laid on cardboard with a rubber cement adhesive.)	Cardboard (Masonite or plywood); rubber cement (Gum Arabic)
(6) Coats one side of cardboard with rubber cement, utilizing a trowel to spread the cement evenly over the entire surface.	Rubber cement; trowel with serrated edge or piece of cardboard
(7) Removes center photo from loose mosaic and coats the back with rubber cement as in preceding paragraph.	
(8) When adhesive dries, mounts center photo face up in the center of the cardboard base.	

TASK ELEMENT		TOOLS AND AIDS REQUIRED
(9)	Removes adjacent photo from loose mosaic and determines where it should be trimmed, bearing in mind that distortion increases toward the edge of the photo, so it should be trimmed as near the center of the overlap as possible, along breaks in terrain such as ditches, roads, edges of fields or woods; in the absence of these, trims photo in areas of blending print tones to minimize the perceptual disparity of the joints.	Cutting tool
(10)	Scores the face of the photo along the pre-determined trim line with a sharp-edged instrument, cutting only through the emulsion.	Cutting tool
(11)	Turns photo face down and tears along scored line, always tearing toward the usable portion of the print, thereby feathering the edge to minimize the surface irregularity of the finished mosaic.	
(12)	Places photo face down near the edge of the work surface and smooths off the feathered edge with a piece of 00 sandpaper.	00 sandpaper
(13)	Positions trimmed photo over center photo and registers its position by drawing grease pencil lines across the intersection of the photos, always starting the lines on the trimmed print and ending them on the mounting print.	Grease pencil
(14)	Applies adhesive to the overlapped portion of the mounted print and the back of the trimmed print.	Rubber cement

TASK ELEMENT		TOOLS AND AIDS REQUIRED
(15)	When adhesive dries, aligns prints with register marks and applies print to the base by pressing with the fingers (or utilizing a print roller).	
(16)	Removes the print from the loose mosaic that was adjacent clockwise to the last print mounted and repeats steps (9) through (15).	
(17)	Continues in the manner of step 16 until all prints have been mounted.	
(18)	Trims one 2-inch and one 3-inch strip of opaque white paper equal to the long dimension of the base.	Paper; straight edge; ruler; lead pencil; shears or cutting tool
(19)	Trims two 2-inch strips of white paper equal to the short dimension of the base.	Same as (18)
(20)	Applies adhesive to the paper strips.	Rubber Cement
(21)	Frames image area by attaching paper strips around the periphery of the base with the 3-inch strip on the bottom.	
(22)	Draws or stamps classification of mosaic at top and bottom.	Colored ink and lettering pen or security classification stamp and ink pad
(23)	Plots coordinates of corners and enters them in the margin.	Coordinate scale; lettering pen and ink
(24)	Determines North direction and draws in North arrow.	Lettering pen and ink
(25)	Stamps or draws title block in lower margin and makes necessary entries.	Title block stamp; ink pad; ruling pen; lettering pen and ink; straight edge

TASK ELEMENT	TOOLS AND AIDS REQUIRED
e. Drop Zone (DZ) Study--A detailed study of an area previously selected from maps or other sources by higher headquarters to determine its suitability as a drop zone.	
(1) Refers to Master Cover Trace to determine which missions cover the area of interest.	Master Cover Trace
(2) Removes photos from photo file.	Photo file
(3) Makes detailed study of photos of the area to determine the existence of obstacles such as trees or tree trunks, fence rows, anti-personnel stakes, or any other obstacles that would prove hazardous to troops or equipment.	Magnifier; stereoscope
(4) Determines height of obstacles around the perimeter of the DZ.	Parallax wedge or stereometer; masking tape
(5) Determines route of egress from the DZ.	
(6) Prepares mosaic of DZ (see paragraph d, above).	See paragraph d, above
(7) Annotates mosaic with information obtained during steps (3), (4) and (5).	
(8) Determines air avenues of approach to DZ and locates easily identifiable checkpoints for the pilot.	Map
(9) Refers to Master Cover Trace to determine which missions cover the checkpoints.	Master Cover Trace
(10) Selects and annotates photos of checkpoints to be used as pilot briefing aids.	Photo file; lettering pen and ink

TASK ELEMENT		TOOLS AND AIDS REQUIRED
f.	Target Folder Preparation--A target folder is a compilation of information obtained from all available sources on a specific point, area, object, or group of objects, at which fire is directed. (Normally the image interpreter is concerned only with the Target Illustration Sheet and part of the Target Information Sheet which form part of the Target Folder.)	
	(1) Obtains Target Illustration Sheet blank form.	Blank forms
	(2) Refers to Master Cover Trace to determine photo coverage of target.	Master Cover Trace
	(3) Removes selected missions from photo file.	Photo file
	(4) Selects photos for inclusion in folder, normally one vertical and two obliques taken from different directions.	
	(5) Trims photos to size with the target as near the center as possible.	Straight edge; Cutting tool
	(6) Affixes prints to Target Illustration Sheet with rubber cement.	Rubber Cement
	(7) Circles target on each of the photos.	Circle template; compass; India ink
	(8) Draws a North arrow on the face of each of the photos.	Lettering pen; ink
	(9) Determines scale of vertical photo by scale line method (locating several pairs of points on the photo which	P. I. scale; P. I. Slide Rule; proportional dividers

TASK ELEMENT	TOOLS AND AIDS REQUIRED
are of approximately equal ground elevations. can be accurately located on the map. are approximately equidistant from the center of photo. are so situated that a line connecting a pair would pass through or near the center of the photo.) Measures the distance between a pair of points on the photo and the same points on the map (all in the same units) and uses the formula: $\text{photo scale} = \frac{\text{map distance X map scale}}{\text{photo distance}}$ Repeats for each pair of points, then determines the average scale of the photo.	
(10) Constructs a graphic scale in the space provided in the Target Illustration Sheet, comparable in scale to the scale of the vertical photo. (See Figure B-34, TM 30-245)	Ruling pen; straight edge; lettering pen; India ink
(11) Stamps appropriate security classification on top and bottom of each page.	Security classification stamp; ink pad

NOTE: All the foregoing tasks apply to imagery acquired from photographic sensors of all types currently in use. However, sensors such as high and low obliques which produce appreciable obliquity in their presentation will require trigonometrical computations to produce valid sizes of imaged objects. Trigonometric tables are provided in TM 30-245, Photo Interpreters Handbook.

TASK ELEMENT	TOOLS AND AIDS REQUIRED
B. Infrared Imagery Interpretation	Light table required for transparencies
1. Plots imagery. Outlines area covered by imagery on a map overlay.	
a. Determines proper map sheet on which to plot the imagery by referring to the pilot's trace or from identifying data on the imagery or by inspection, relying upon the interpreter's familiarity with the area imaged.	Maps; pilot's trace
b. Places sheet of tracing paper over map and fastens map to drawing board.	Tracing paper; drawing board; masking tape
c. Registers overlay by drawing intersecting grid lines in two diagonal corners of the overlay.	Lead pencil; straight edge
d. Determines scale of imagery along the flight line by measuring the distance between two identifiable points parallel to the line of flight on the imagery and measuring the distance between the same points on the map (all in the same units); uses the same formula as with photographic imagery scaling.	P. I. scale; pencil and paper or P. I. slide rule; tube magnifier
e. Prints or stamps in title block.	Lead pencil; title block stamp; ink pad
f. Locates area covered by imagery on map by inspection.	
g. Outlines the area(s) covered by the imagery on the overlay utilizing a straight edge.	Straight edge
h. Numbers outlined area(s) with run number(s) from pilot's trace.	Pencil
i. Prints or stamps security classification on top and bottom of overlay.	Colored pencil or security classification stamp and colored ink pad

TASK ELEMENT	TOOLS AND AIDS REQUIRED
2. Master Cover Trace. The Master Cover Trace for Infra-Red imagery is prepared in the same manner as the Master Cover Trace of photo imagery (paragraph A, 2); however, it is a separate trace.	
3. Hot Report. A Hot Report on IR imagery is handled in the same manner as with photo imagery (paragraph A, 3) with the following exceptions:	
a. Scans imagery quickly, detecting man-made objects on the basis of size, shape, shadow, shade, surroundings, and signal strength. Because of imagery peculiarities caused by features inherent in IR sensors, most recent photo coverage of imaged areas should always be checked whenever possible.	Photo files
b. If the sensor produces stereo imagery, uses appropriate viewing device to take advantage of the third dimensional aspect as an aid in the identification of detected objects.	
4. Immediate Report. An Immediate Report on IR imagery is handled in the same manner as with photo imagery (paragraph A, 4) with two exceptions as noted in paragraph B, 3, above.	
5. Additional Reports. Normally the Immediate is the last report made on IR imagery; however, an Immediate Report may be a source of information for a Summary, Detailed, or Special Report, in which case it would be treated the same as photo imagery with the exceptions as outlined in paragraph B, 3, above.	
C. Side-Looking Airborne Radar (SLAR) Imagery Interpretation	Light table required for transparencies
1. Plots imagery. Outlines area covered by imagery on a map overlay.	

TASK ELEMENT	TOOLS AND AIDS REQUIRED
a. Determines proper map sheet on which to plot the imagery by referring to the pilot's trace or to identifying data on the imagery or by inspection of the imagery.	Maps; pilot's trace
b. Places sheet of tracing paper over map and fastens map to drawing board.	Tracing paper; drawing board; masking tape
c. Registers overlay by drawing intersecting grid lines in two diagonal corners of the overlay.	Lead pencil; straight edge
d. Determines scale of imagery by measuring the distance between two identifiable points on the imagery and measuring the distance between the same points on the map (all in the same units); uses the same formula as with photographic imagery scaling.	P. I. scale; pencil and paper or P. I. slide rule; tube magnifier
e. Prints or stamps in title block.	Lead pencil; title block stamp and ink pad
f. Locates area covered by imagery on map by inspection.	
g. Outlines the area(s) covered by the imagery on the overlay, using a straight edge.	Lead pencil; straight edge
h. Numbers outlined area(s) with run number(s) from pilot's trace.	Lead pencil
i. Prints or stamps security classification on top and bottom of overlay.	Colored pencil or security classification stamp and colored ink pad

2. Master Cover Trace. The Master Cover Trace for SLAR imagery is prepared in the same manner as the Master Cover Trace of photo imagery (paragraph A, 2); however, it is a separate trace.

TASK ELEMENT	TOOLS AND AIDS REQUIRED
3. Hot Report. A Hot Report on SLAR imagery is handled in the same manner as on photo imagery (paragraph A, 3), with the following exceptions:	
a. Scans imagery quickly, detecting man-made objects on the basis of size, shape, shade, signal strength, and surroundings; also detecting moving objects by their "blips" on the MTI presentation of the imagery.	
b. Measures length and width of objects with interpreter's scale or tube magnifier to assist in identification, bearing in mind that certain target types require the addition or subtraction of one beam width to or from the total dimension of the targets.	P. I. scales; tube magnifier; keys
4. Additional Reports. Normally the Hot Report is the only report made on SLAR imagery; however, the Hot Report may be a source of additional information for inclusion in a Summary, Detailed, or Special Report.	

APPENDIX B. IMPROVED TUBE MAGNIFIER RETICLES FOR MENSURATION OF SMALL OBJECTS

Three new configurations of tube magnifier reticles[1] were designed and are proposed for use. These configurations were designed to overcome certain disadvantages of present reticles. The existing devices require the user to perform a number of activities simultaneously which are both time-consuming and sources of error:

1. Establishing the zero index at one end of the object to be measured. Many reticle scales run clear across the field of view; accurately setting the zero index, which is near the periphery of the reticle, produces an uncomfortable "pulling" sensation in the eye due to the optical qualities of the tube magnifier lens [The proposed reticles have the zero index closer to the center of the field of view.]

2. Alignment of the scale along the axis of the object to be measured. If the scale is placed on top of the object it tends to obscure the object, necessitating movement of the reticle so that both ends of the object are visible. Such manipulation usually requires resetting of the zero index.

3. Repeated shifting of the visual focal point between the trailing end of the object and the scale. Interpolation is usually required, and repeated shifts of the focal point are necessary for verification. In addition, with some photographic imagery, the numerical scale blends in with the background and can not be read easily. In an attempt to overcome this difficulty, scales of different colors have been made to provide more contrast. However, this solution has not been entirely satisfactory, since an increase in scale contrast in the middle of the field of view also produces an increase in distractability when locating objects beyond the reticle plane.

The three mensuration reticle configurations which are described below permit the elements of the mensuration task to be performed consecutively. In each case, measurements are made as follows:

a. The axis line is placed over the axis of the object to be measured so that the line intersects the points between which the size is to be determined.

b. The reticle is slid in the direction of the axis line until the zero index line appears to just touch one end of the object.

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[1] Patents are being applied for on these reticle designs.

c. The index line is manipulated until it appears to just touch the other end of the object.

d. The value is read where the index line intersects the numerical scale. If the background does not provide enough contrast to read the scale, the reticle can be moved elsewhere--over a piece of white paper, for instance,

Figure B-1 shows a design which utilizes a clear plastic lever to carry the index line. An important advantage of this design is that an expanded scale (relative to the size of the object) can be used for easier reading.

Figure B-2 shows another design wherein the movable member can be removed completely, or gross adjustment of the index line can be made quickly by placing the thumb on part A and the index finger on part B. When part B is squeezed towards part A, the screw threads become disengaged from the threads in the housing ring and gross movements can be made. For fine adjustments the knurled part of the screw can be turned with the tip of the index finger.

In the third design (Figure B-3), the index line is traversed across the field of view by turning the knurled knob which is attached to a flexible shaft which in turn is connected to the screw.

With these devices it is expected that considerable time can be saved in imagery interpretation where the operational situation requires the location of objects of a given size. By setting the index line at the desired size, imaged objects of that size (or larger, or smaller) can be quickly determined by visual comparison without the need for measuring each object.

The drawings in Figures B-1, B-2, and B-3 are scaled 2:1, except for the insets which are scaled approximately 1:1. These particular configurations are designed to fit a Bausch and Lomb 7X Tube Magnifier,[2] but they could be made for use with other optic systems.

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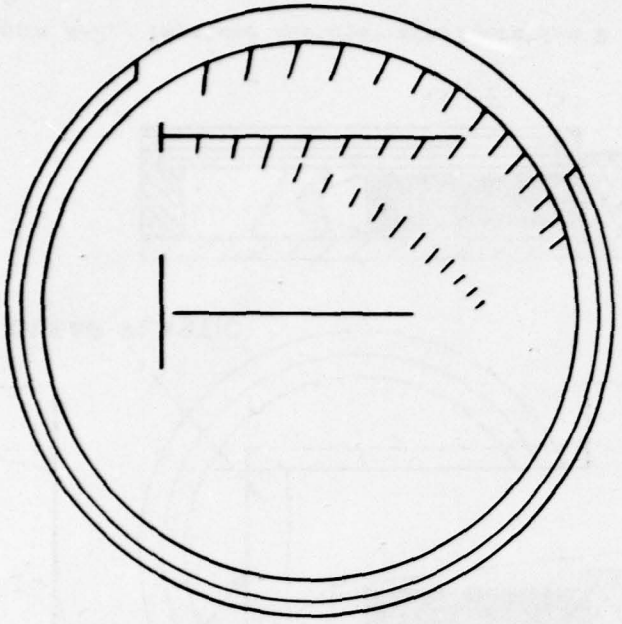
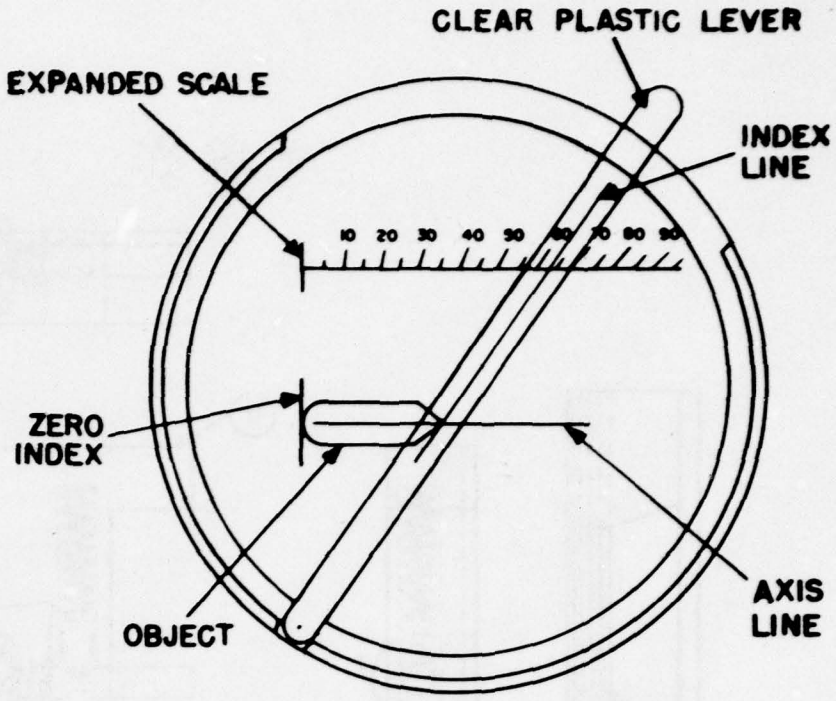
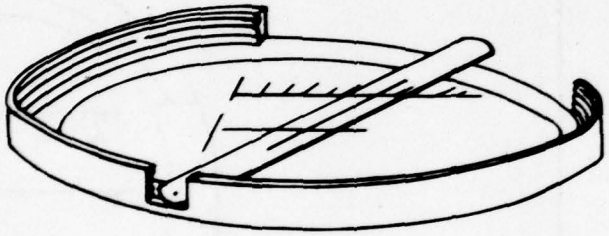
[2] Identification of equipment by trade name is in the interest of precision in reporting procedures and does not constitute indorsement by BESRL or the Department of the Army.





ALTERNATE TYPES OF SCALES



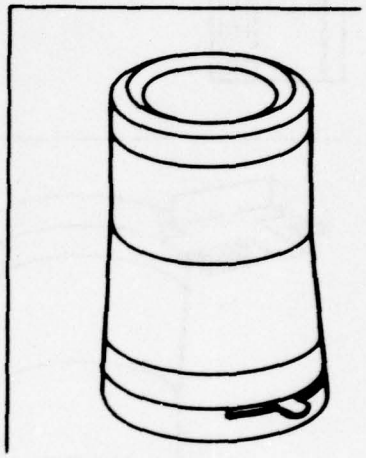


Figure B-1. Improved reticle--configuration A

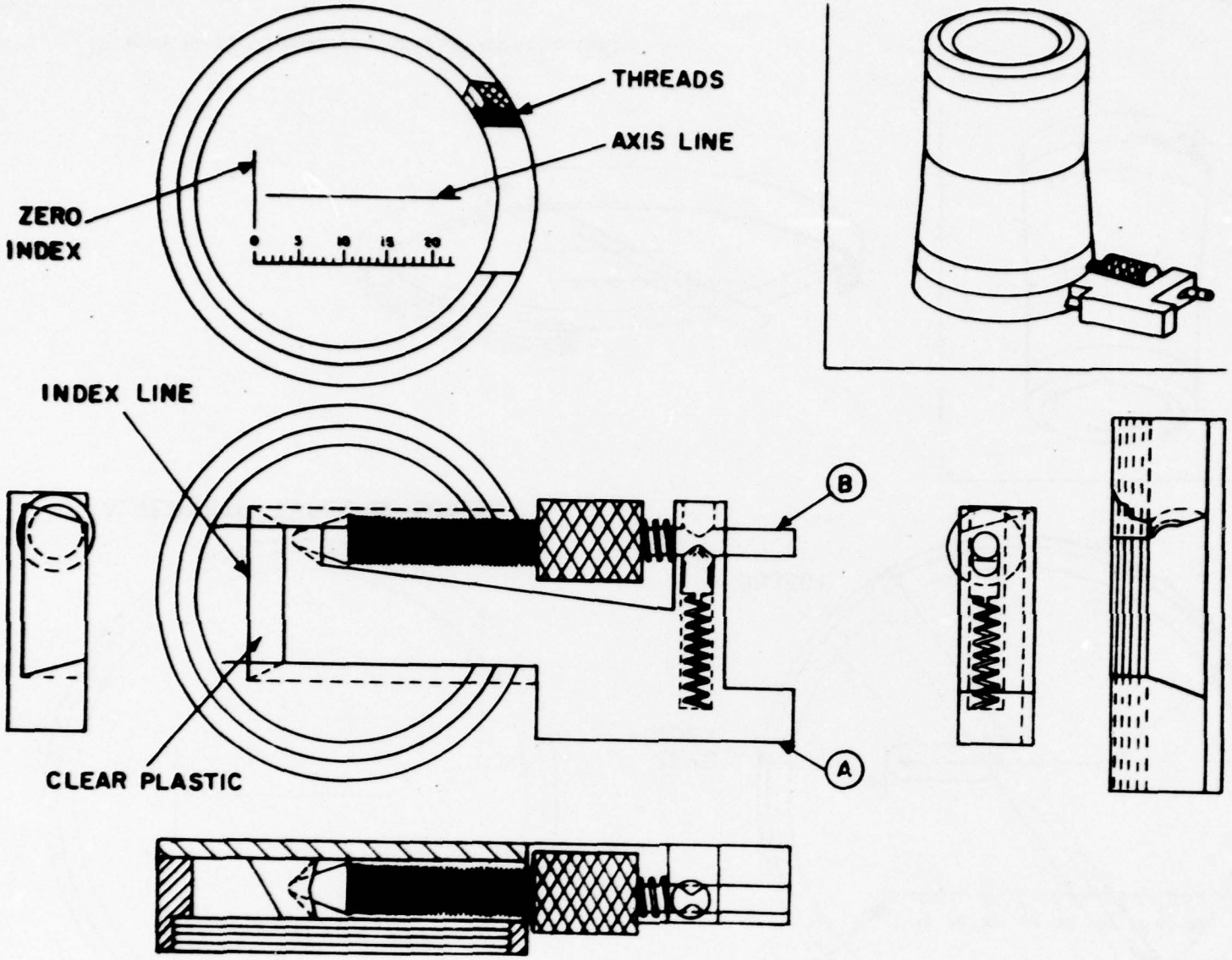


Figure B-2. Improved reticle--configuration B

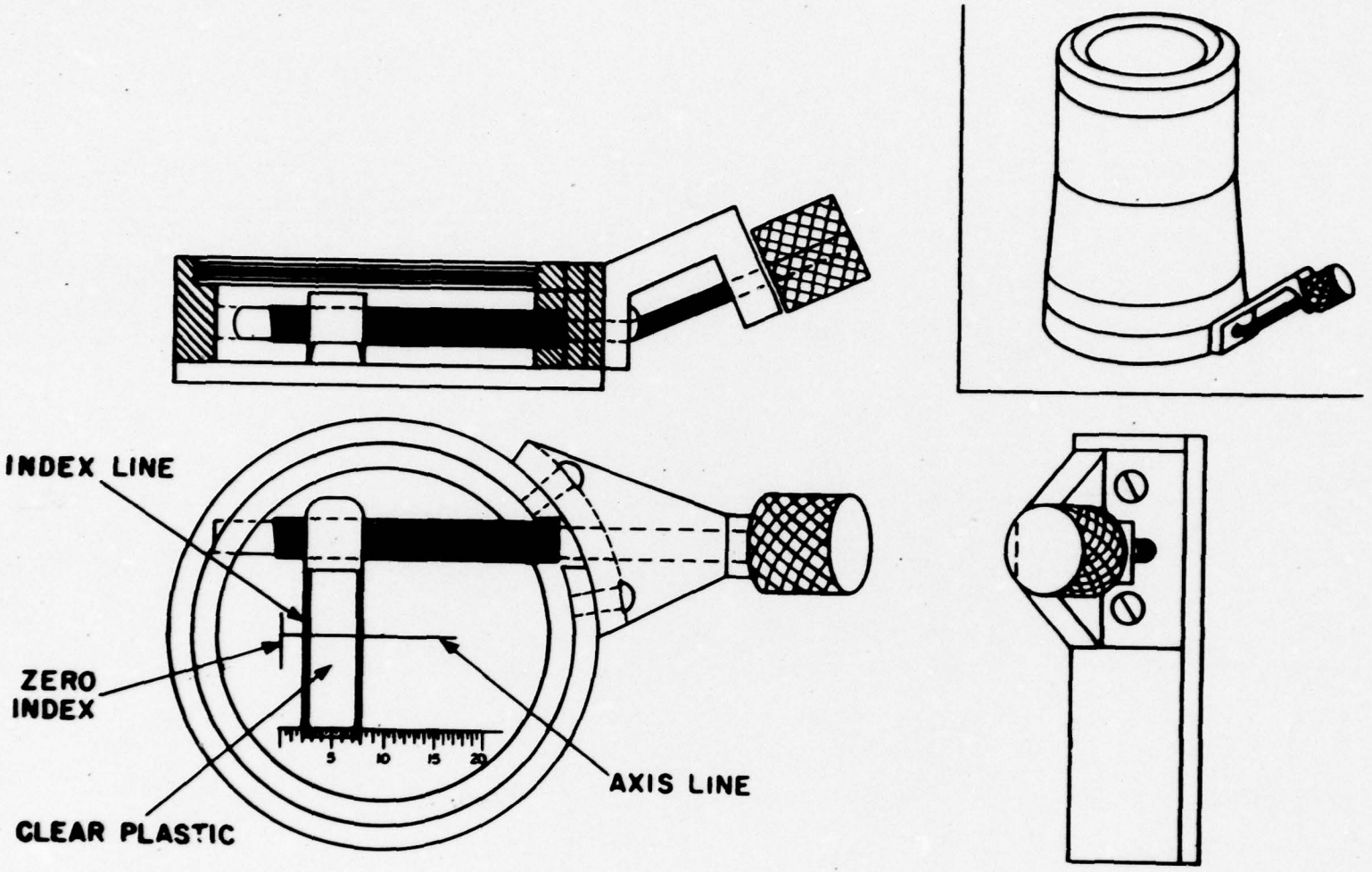


Figure B-3. Improved reticle--configuration C

APPENDIX C. CONSTRUCTION OF PLOTTING TEMPLATES

PLOTTING TEMPLATE FOR THE HYCON KA-55 HI-PAN CAMERA SYSTEM[1]

The KA-55 Hi-Pan Camera System is normally used in the vertical configuration. The view angle for this 12-inch focal length camera covers an area subtended by 21 degrees 14 minutes x 90 degrees. The size of each frame of imagery is 4.5 x 18.9 inches.

In making plots of photographic imagery area coverage on map overlays, a plotting template is an invaluable aid. The shape of the geographic area covered by a given frame of panoramic imagery is far from being a simple rectangle since the northings get progressively larger as the eastings get further from the nadir. Determination of the exact shape of ground area coverage can be made straight-forwardly from the imagery overlay grid usually provided by the camera manufacturer. But in the case of the KA-55 camera system, no such grid has been made available; an alternate approach to the determination of ground area coverage was therefore developed using the AR-85A Viewer-Computer as follows:

A fine line rectangle was constructed to the dimensions of a single frame of KA-55 imagery (4.5 x 18.9 inches) on a piece of clear acetate. The overlay was affixed to a 1:50,000 scale map sheet. Then, short tic marks were inscribed at alternate 1,000-meter UTM grid lines along each of the long side dimensions.[2] Thirteen points with twelve 4-cm intervals were thus obtained. On the short side dimensions, the center points were established as well as the center point corresponding to the nadir.

In order to use the program in the Field Artillery Data Computer (FADAC) to calculate the UTM coordinates of each selected point around the periphery of the simulated imagery, two known geographical points were established. To obtain these points, the simulated imagery was placed on the x-y motion of the AR-85A. Arbitrary 10-place UTM coordinates of the lower center tic mark were mathematically determined relative to the arbitrary nadir coordinates and these were also entered into the computer. In addition, other parameters required by the computer program were provided as entries. These were:

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[1] Commercial names are used only for specificity in stating the intended use of the templates devised. Mention does not constitute indorsement by the Department of the Army or by BESRL.

[2] This procedure should have produced tic marks 4.0 cm apart. However, actual measurement indicated that these increments were slightly smaller (on the order of 3.991). The discrepancy was taken to be caused by a small amount of map shrinkage.

Aircraft altitude	=	50,000 feet
Focal length	=	12 inches
Scan velocity rate	=	185.95 deg/sec
Aircraft velocity	=	0
Velocity/Height (V/H)	=	0

The forward motion compensation feature in the KA-55 is designed to negate the ground distortion usually found on panoramic imagery caused by the forward motion of the sensor platform. At the time the present problem was introduced into the computer, the program in use (dated 30 September 1966) did not accurately compensate for forward motion of this particular sensor. In a previous pilot study, an aircraft velocity of 360 knots was used. When the pilot study data were plotted for a straight center line perpendicular to the aircraft heading, a slightly S-shaped curve was obtained instead of an expected straight line. By using an aircraft velocity of zero (and V/H = 0) this discrepancy was eliminated. In the latter part of February 1968, shortly after the present data were calculated, a new computer program was approved which presumably makes better compensation for forward motion with KA-55 inputs.

The reticle on the x-y motion table was positioned under each of the tic marks in turn, and the UTM ground coordinates were read from the digital display panel on the computer. The entire operation was replicated two more times. The three coordinate readings for each tic mark were averaged to minimize reticle positioning inaccuracies. The maximum deviation in reticle positioning equaled only four meters in ground distance.

Next, UTM coordinates were converted to ground distances in feet from the x axis and the y axis of the nadir location. These distances were then divided by the map scale to convert them to the decimal equivalents of a foot. The latter values are shown in Table C-1. A plot of these measures on a map overlay (scale 1:50,000) determined the shape and size of the area coverage. Using this configuration as a base, another plot was made to determine the shape and size of the area coverage for a camera altitude of 10,000 feet. (For evaluative purposes it was decided to build the template to accommodate sensor altitudes up to and including 10,000 feet.) Figure C-1 shows the result of this plot. The center scale is 1:10,000, corresponding, on a map scale of 1:50,000, to a y axis ground distance of 3,750 feet at the center. Because of the expansion of area coverage at the left and right extremes, the y axis ground distance expands to 5,303 feet. The lateral ground distance, along the x axis, covers 10,000 feet on each side of the nadir. There are some minute discrepancies between the ground distances stated above (which were determined trigonometrically) and those which can be calculated from data in Table C-1. The tabled data are known to contain very slight inaccuracies due to uncontrollable drafting deviations in the simulated imagery. The errors are of a magnitude not exceeding .0012 foot, a value roughly equivalent to the thickness of a pencil line used in making a plot.

Table C-1

THE OBTAINED x-y COORDINATES FOR THE SELECTED PERIPHERAL POINTS ON KA-55 SIMULATED IMAGERY

(IN DECIMAL EQUIVALENTS OF A FOOT)

Position Number[a]	x axis	y axis	Position Number	x axis	y axis
1.	-.20039	+.05377	15.	+.20040	-.05379
2.	-.15385	+.04790	16.	+.15386	-.04792
3.	-.11570	+.04397	17.	+.11569	-.04395
4.	-.08302	+.04122	18.	+.08306	-.04123
5.	-.05384	+.03946	19.	+.05383	-.03944
6.	-.02653	+.03832	20.	+.02653	-.03839
7.	-.00000	+.03755	21	+.00007	-.03806
8.	+.02646	+.03786	22.	-.02647	-.03817
9.	+.05370	+.03889	23.	-.05370	-.03889
10.	+.08301	+.04068	24.	-.08303	-.04069
11.	+.11564	+.04339	25.	-.11564	-.04337
12.	+.15375	+.04740	26.	-.15376	-.04740
13.	+.20029	+.05317	27.	-.20029	-.05317
14.	+.20036	-.00013	28.	-.20034	+.00010

[a] Position Number 1 = Upper left corner
Position Number 13 = Upper right corner
Position Number 14 = Left center
Position Number 15 = Lower left corner
Position Number 27 = Lower right corner
Position Number 28 = Right center

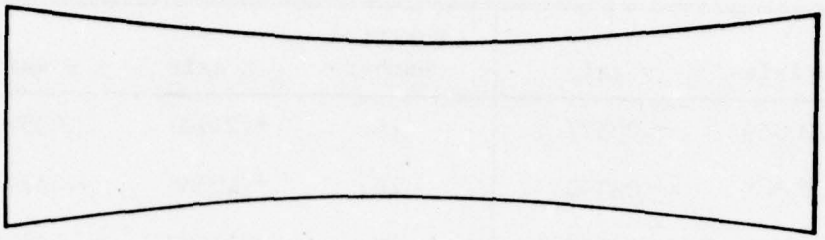


Figure C-1. Map area coverage (scale 1:50,000) for KA-55 Camera System with Center scale 1:10,000

A plastic plotting template was constructed based on the geometry in Figure C-1. By making the calculations necessary for camera altitudes lower than 10,000 feet, it was possible to inscribe index marks on the template (in one thousand-foot increments) so that it could be used for plotting imagery at these altitudes. In reality, the geometric shape of the curves will change slightly with other altitudes, but the 10,000-foot curve provides an approximation close enough to be useful for the altitudes selected for this particular template. The lateral settings at all altitudes are accurate, however. Obviously, templates to cover other altitude ranges can be similarly developed and constructed. Figure C-2 shows the present configuration of the KA-55 Plotting Template set for a 10,000-foot sensor altitude.

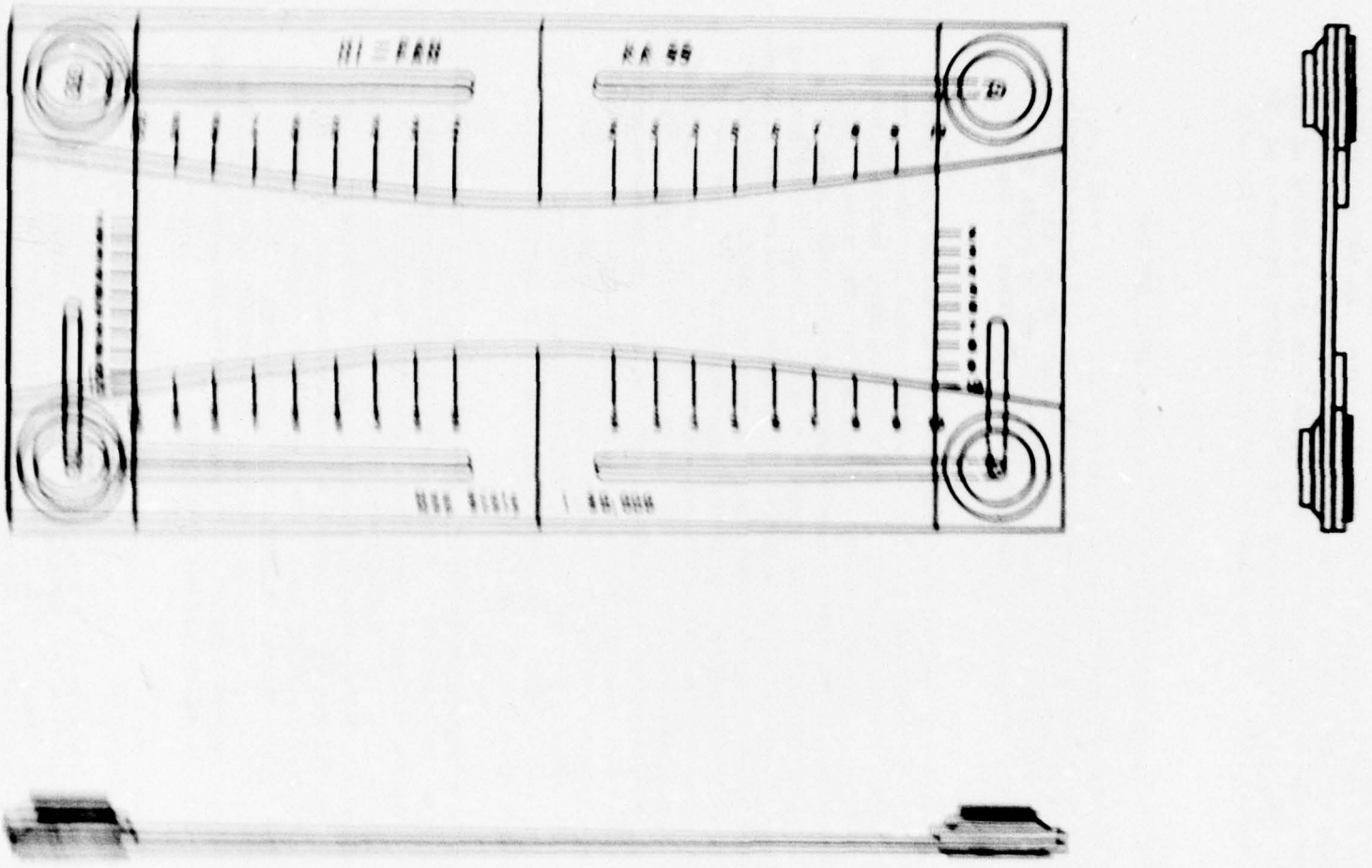
To use the template for plotting purposes, all that need be known, assuming level flight, is the altitude at which the imagery was taken. To set up the template for, say a 5,000-foot altitude, the following steps should be taken:

1. Loosen all four thumb screws.

2. Slide inside edges of the two side pieces to the "5" index marks on the top piece and tighten top two screws.

3. Slide the bottom piece up and match the two "5" index marks on the bottom piece with the respective left side and right side "5" index marks.

4. Tighten all screws and check alignment and settings.



The plotting practices and techniques used with standard rectangular plotting templates can be employed with this template. An important feature which contributes to the ease of using the KA-55 plotting template is the inscribed center line. The center line coincides with the heading of the sensor aircraft and, in those instances where the heading is known or can be closely estimated, aids in the azimuthal orientation of the plotting template.

PLOTTING TEMPLATE FOR THE FAIRCHILD KA-56 LOW-PAN CAMERA SYSTEM[3]

The KA-56 Low-Pan Camera System is primarily used in the vertical position. This camera has a 75-mm. focal length; the view angle beneath the sensor platform laterally covers an area subtended by an arc of 180 degrees which is 74 degrees wide. Each 180-degree sweep includes the horizon on both sides. The size of the format of each frame of imagery is 4.5 x 9.4 inches.[4]

The size and shape of map area coverage for any given altitude can be derived by mathematical computation. The measures needed for these computations include focal length, altitude, scan velocity rate, sensor platform velocity, variation of image motion compensation across the imagery, and frame format dimensions. The camera manufacturer has developed a KA-56 Panoramic Photography Coordinate Grid imagery overlay for use in determining ground distances. To avoid making a number of lengthy calculations to establish the size and shape of ground coverage, the grid was used. A series of curves were plotted to determine the ground area coverage for a number of altitudes. The curve for each altitude was based on the x-y coordinates of points along a line connecting the top two index marks on the grid. The procedure was to read selected coordinate points in terms of representative ground distance in feet from the grid's vertical and horizontal centerlines. These values were then multiplied by camera altitude in hundreds of feet and divided by the map scale (1:50,000) resulting in map distances in decimal equivalents of a foot. The coordinate values in map distance for selected altitudes are shown in Table C-2.

Curves were constructed based on the data in Table C-2. These curves are shown in Figures C-3 and C-4. The shape of the curve changes with altitude; also, the two halves of each curve are not symmetrical due to distortion resulting from the forward motion of the sensor platform which has not been completely eliminated by the Image Motion Compensator. The 1,000-foot curve in Figure C-3 was chosen as best representing the family of curves from 500 feet to 2,000 feet. The 3,500-foot curve in Figure C-4 was chosen as best representing the family of curves from 2,000 feet to 5,000 feet. These chosen curves were used in the construction of two templates made from transparent plastic. The second curve in each template was obtained by rotating the first curve 180 degrees.

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[3] See footnote 1 on page 41.

[4] There is a slight discrepancy between the numbers cited above, which were taken from the KA-56 Operating Manual, and actual calculations using a 75-mm. focal length lens. If the 75-mm. focal length lens is used, then the width of the field of view figures to be 74° 38', and the length of the format of each frame is 9.28 inches. Apparently, a 3-inch focal length lens was used for the calculations given in the manual.

Curve separations for use with a 1:50,000 map scale for the selected altitudes were calculated by multiplying the grid's vertical center line ground distance in feet from the nadir by the camera altitude in hundreds of feet, dividing by 50,000 to convert to decimal equivalents of a foot, and doubling this value. To set the template, all that need be known is the camera altitude above the terrain. On both curves of the template, ground distance tic marks are inscribed to show each thousand feet of ground distance from the vertical center line of the plot.

Figure C-5 shows a template design for camera altitudes up to 2,000 feet. The template in this drawing is set for an altitude of 1,000 feet.

Figure C-6 depicts the second template design which accommodates camera altitudes between 2,000 and 5,000 feet. This template is adjusted for an altitude of 3,500.

Plots are made with either of these templates by first loosening the two thumb screws, setting the camera altitude opposite the index marks on both sides, and then tightening both thumb screws. The area covered by the frame of imagery to be plotted is then located on the appropriate map. If the frame of imagery contains a data block, the aircraft's true heading is determined and the center line of the template is oriented in this direction on the overlay. If possible, an object is located on the map on or near the vertical center line of the imagery. While maintaining the azimuthal orientation, the template is then shifted until the known object on the map is positioned in the template opening relative to the position of the object on the imagery, taking into account the distortion of the imaged area. In the event the true heading of the aircraft cannot be determined initially, the template can be oriented using the relative positions of two or more imaged objects. Once this has been accomplished, the center line of the template will be aligned with the true heading of the aircraft and this information can be used in plotting other frames of the same run.

After the template is properly positioned, the curves are drawn on the overlay out to the desired ground distance using the ground distance tic marks as guides. Since it is present plotting procedure to show oblique photographs which include the horizon as an open-ended figure (⊏), the curves for the KA-56 plot are drawn in a similar manner except that the plot is double open-ended. The curves in the template have been extended far enough to include a ground distance from the nadir which exceeds the practical limit of tactical interpretability.

AN ADJUSTABLE PLOTTING TEMPLATE FOR THE FAIRCHILD KA-60 PANORAMIC CAMERA SYSTEM[6]

A template of this type is used as an aid in plotting ground area coverage on map overlays when the KA-60 camera is employed in the vertical position. The lateral sweep of this camera is 180 degrees and the width of the field of view subtends an angle of 41° 16' with a 3-inch focal length lens. The size of the format of each frame of imagery is 2.25 x 9.4 inches.

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[5] See footnote 1 on page 41.

Table C-2

THE x-y COORDINATES FOR THE SELECTED PERIPHERAL POINTS ON KA-56 PANORAMIC PHOTOGRAPHIC COORDINATE GRID AT THE INDICATED ALTITUDES

(IN DECIMAL EQUIVALENTS OF A FOOT IN 1:50,000 SCALE MAP DISTANCES)

500' Altitude		1000' Altitude		2000' Altitude		3000' Altitude		3500' Altitude		4000' Altitude		5000' Altitude	
x axis	y axis	x axis	y axis	x axis	y axis	x axis	y axis	x axis	y axis	x axis	y axis	x axis	y axis
-.0600'	.0410'	-.1200'	.0820'	-.2400'	.1640'	-.3600'	.2460'	-.4200'	.2870	-.4800'	.3280'	-.6000'	.4100'
-.0300'	.0220'	-.0600'	.0440'	-.1200'	.0880'	-.1800'	.1320'	-.2100'	.1540'	-.2400'	.1760'	-.3000'	.2200'
-.0180'	.0150'	-.0360'	.0300'	-.0720'	.0600'	-.1080'	.0900'	-.1260'	.1050'	-.1440'	.1200'	-.1800'	.1500'
-.0090'	.0102'	-.0180'	.0204'	-.0360'	.0408'	-.0540'	.0612'	-.0630'	.0714'	-.0720'	.0816'	-.0900	.1020'
-.0060'	.0088'	-.0120'	.0176'	-.0240'	.0352'	-.0360'	.0528'	-.0420'	.0616'	-.0480'	.0704'	-.0600	.0880'
0	.0076'	0	.0152'	0	.0304'	0	.0456'	0	.0532'	0	.0608'	0	.0760'
.0060'	.0090'	.0120'	.0180'	.0240'	.0360'	.0360'	.0540'	.0420'	.0630'	.0480'	.0720'	.0600'	.0900'
.0100'	.0110'	.0200'	.0220'	.0400'	.0440'	.0600'	.0660'	.0700'	.0770'	.0800'	.0880'	.1000'	.1100'
.0160'	.0150'	.0320'	.0300'	.0640'	.0600'	.0960'	.0900'	.1120'	.1050'	.1280	.1200'	.1600'	.1500'
.0200'	.0180'	.0400'	.0360'	.0800'	.0720'	.1200'	.1080'	.1400'	.1260'	.1600'	.1440'	.2000'	.1800'
.0280'	.0243'	.0560'	.0468'	.1120'	.0972'	.1680'	.1458'	.1960'	.1701'	.2240'	.1944'	.2800'	.2430'
.0600'	.0500'	.1200	.1000'	.2400'	.2000'	.3600'	.3000'	.4200'	.3500'	.4800'	.4000'	.6000'	.5000'

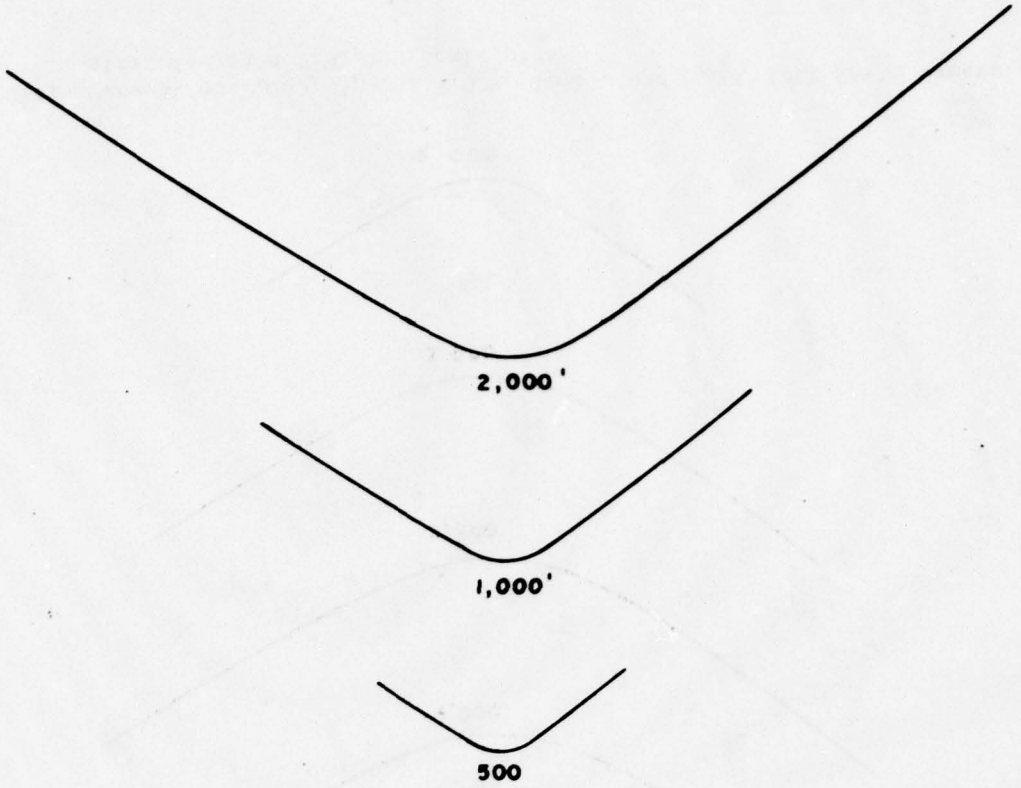


Figure C-3. Curves for 500, 1,000, and 2,000 foot KA-56 Camera altitudes on a 1:50,000 scale plot

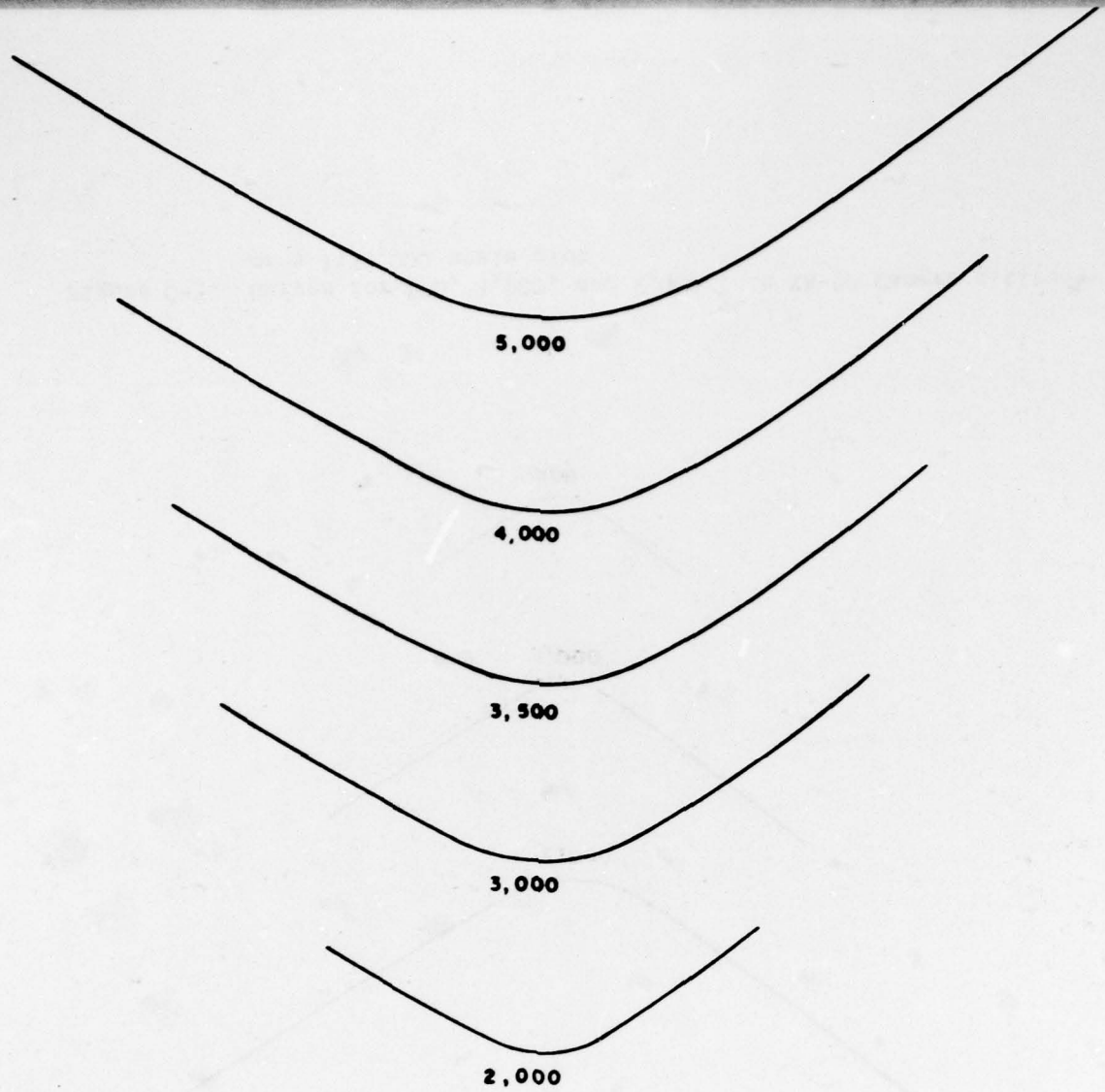


Figure C-4. Curves for 2,000, 3,000, 3,500, 4,000, and 5,000 foot KA-56 Camera altitudes on a 1:50,000 scale plot

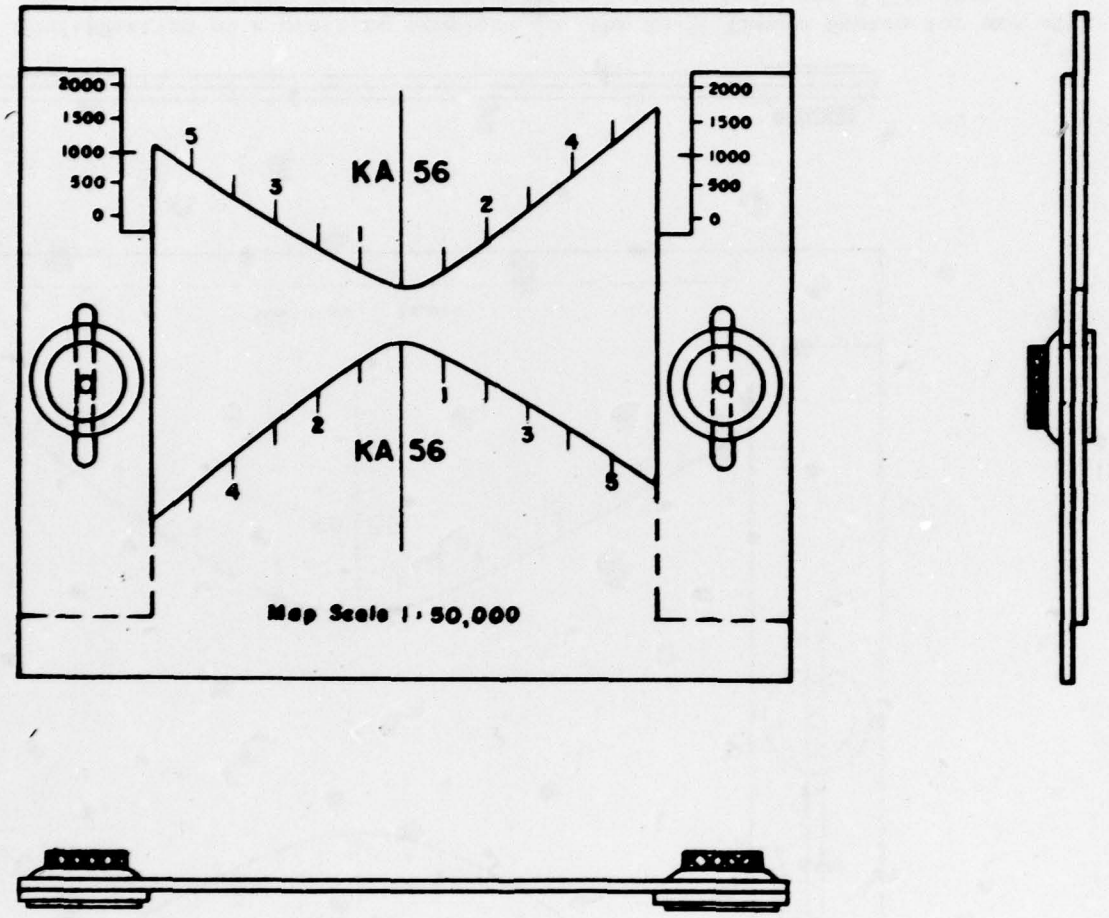


Figure C-5. Configuration of a plotting template for the KA-56 Camera System for use with 1:50,000 scale plots and camera altitudes up to 2,000 feet

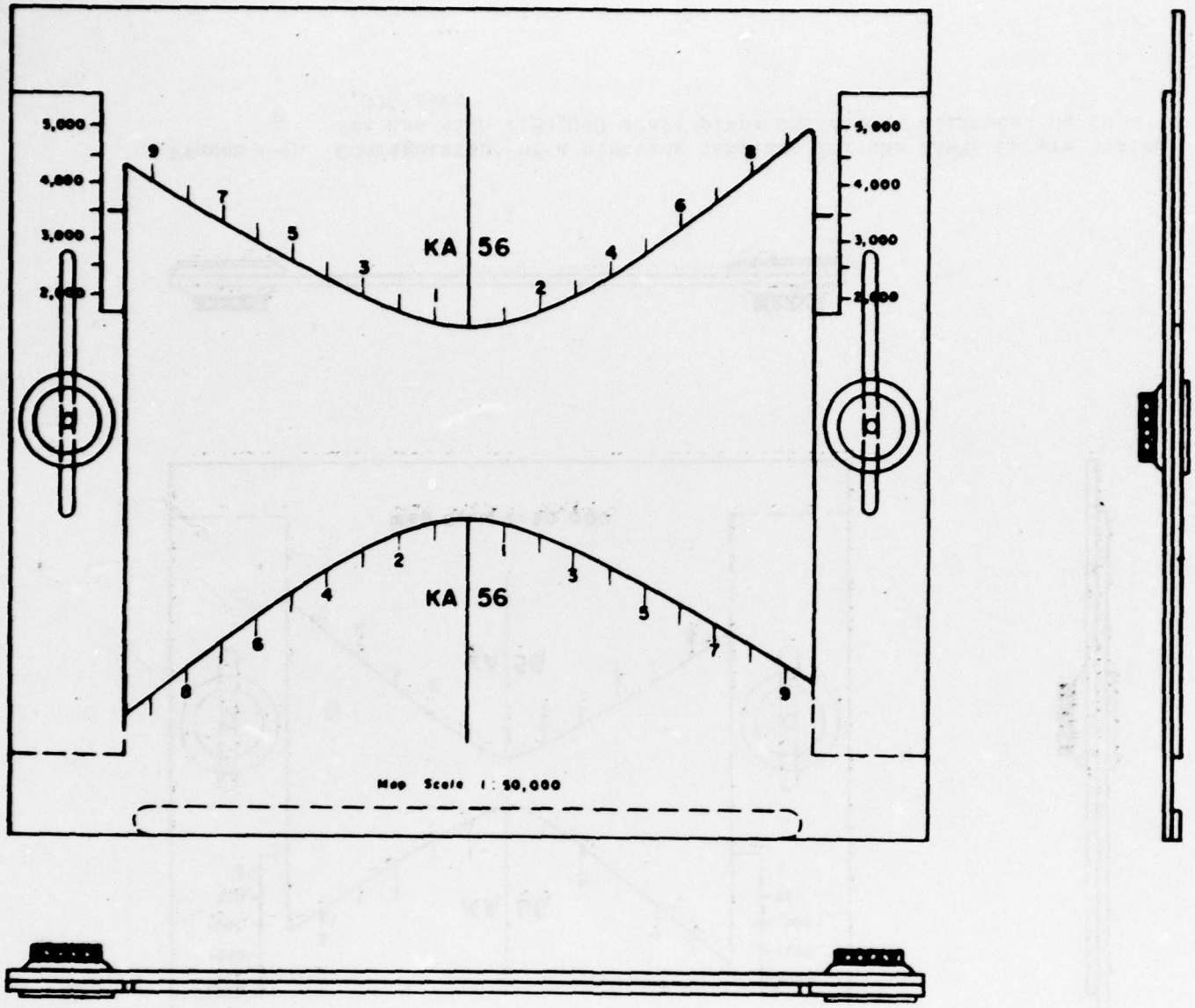


Figure C-6. Configuration of a plotting template for the KA-56 Camera System for use with 1:50,000 scale plots and camera altitudes between 2,000 and 5,000 feet

The size and shape of map area coverage for any given altitude can be derived by mathematical computation. The measures needed for these computations include focal length, altitude, scan velocity rate, sensor platform velocity, and frame format dimensions. The camera manufacturer has developed a KA-60 Panoramic Photography Coordinate Grid (vertical orientation) imagery overlay for use in determining ground distances. The grid was used to avoid making a number of lengthy calculations to establish the size and shape of ground coverage. A series of curves was plotted to determine the ground area coverage for a number of altitudes. The curve for each altitude was based on the x-y coordinates of points along a line connecting the top two index marks on the grid. The procedure was to read selected coordinate points in terms of representative ground distances in feet from the grid's vertical and horizontal centerlines. These values were then multiplied by camera altitude in hundreds of feet and divided by the map scale (1:50,000) resulting in map distances in decimal equivalents of a foot.

Curves were constructed based on the data in Table C-3. These curves are shown in Figure C-7. The shape of the curve changes with altitude; also, the two halves of each curve are not symmetrical because of distortion resulting from the forward motion of the sensor platform--distortion which has not been completely eliminated by the Image Motion Compensator. The 1,000-foot curve in Figure C-7 was chosen as best representing the family of curves from 500 feet to 2,000 feet. This chosen curve was used in the construction of a template made from transparent plastic. The second curve in each template was obtained by rotating the first curve 180 degrees.

Curve separations for use with a 1:50,000 map scale for the selected altitudes were calculated by multiplying the grid's vertical center line ground distance in feet from the nadir by the camera altitude in hundreds of feet, dividing by 50,000 to convert to decimal equivalents of a foot, and doubling this value. To set the template, all that need be known is the camera altitude above the terrain. On both curves of the template, ground distance tic marks are inscribed to show each thousand feet of ground distance from the vertical center line of the plot.

Figure C-8 shows the template design for plotting imagery taken with the KA-60 Panoramic Camera in the vertical position for sensor altitudes up to 2,000 feet. Plots are made with this template by first loosening the two thumb screws, setting the camera altitude opposite the index on both sides, and then tightening both thumb screws. The area covered by the frame of imagery to be plotted is then located on the appropriate map. If the frame of imagery contains a data block, the aircraft's true heading is determined and the center line of the template is oriented in this direction on the overlay. If possible, an object is located on the map at or near the vertical center line of the imagery. Maintaining the azimuthal orientation, the template is shifted until the known object on the map is positioned in the template opening relative to the position of the object on the imagery, taking into account the distortion of the imaged area. In the event the true heading of the aircraft cannot be determined initially, then the template can be oriented using the relative positions of two or more imaged objects. Once this has been accomplished, the centerline of the template will be aligned with the true heading of the aircraft and this information can be used in plotting other frames of the same run.

Table C-3

THE x-y COORDINATES FOR THE SELECTED PERIPHERAL POINTS ON KA-60 PANORAMIC PHOTOGRAPHIC COORDINATE GRID AT THE INDICATED ALTITUDES

(IN DECIMAL EQUIVALENTS OF A FOOT IN 1:50,000 SCALE MAP DISTANCES)

500' Altitude		1000' Altitude		2000' Altitude	
x axis	y axis	x axis	y axis	x axis	y axis
-.0800'	.0290'	-.1600'	.0580'	-.3200'	.1160'
-.0500'	.0812'	-.1000'	.0364'	-.2000'	.0728'
-.0250'	.0099'	-.0500'	.0198'	-.1000'	.0396'
-.0160'	.0070'	-.0320'	.0140'	-.0640'	.0280'
-.0090'	.0050'	-.0180'	.0100'	-.0360'	.0200'
-.0040'	.0040'	-.0080'	.0080'	-.0160'	.0160'
0	.0037'	0	.0074'	0	.0148'
.0040'	.0041'	.0080'	.0082'	.0160'	.0164'
.0080'	.0048'	.0160'	.0096'	.0320'	.0192'
.0120'	.0060'	.0240'	.0120'	.0480'	.0240'
.0180'	.0080'	.0360'	.0160'	.0720'	.0320'
.0400'	.0161'	.0800'	.0322'	.1600'	.0644'
.0800'	.0310'	.1600'	.0620'	.3200'	.1240'

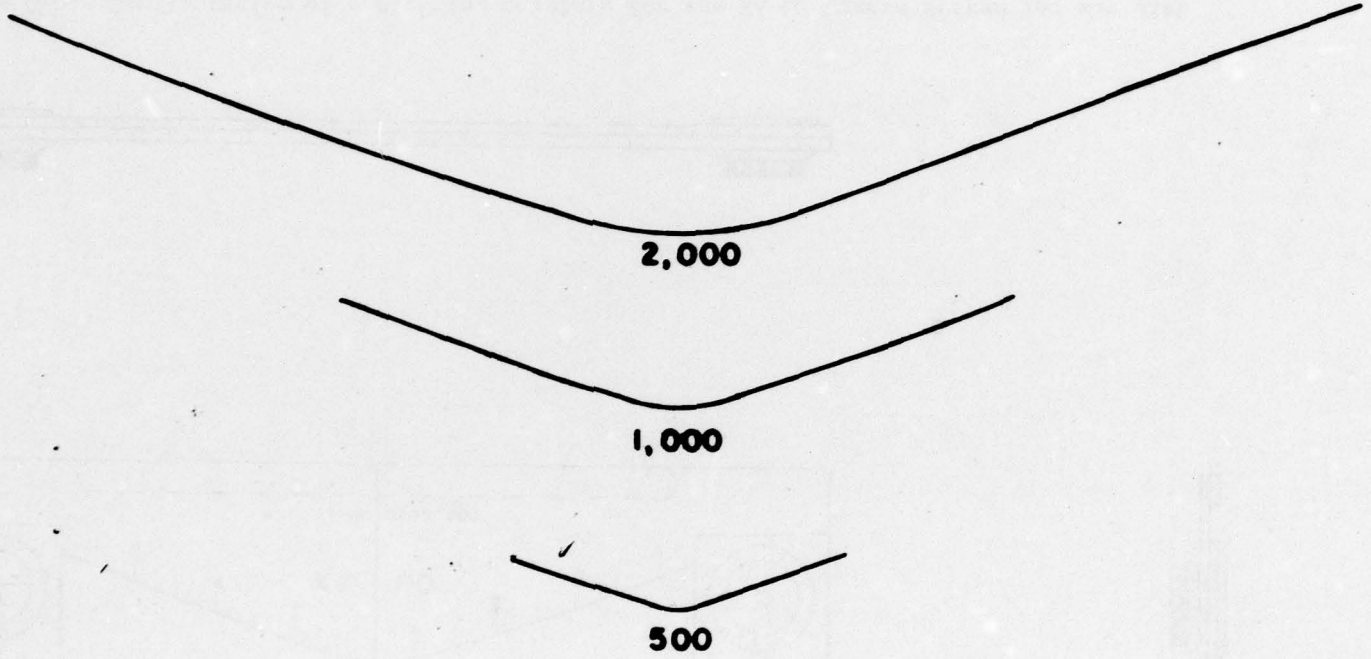


Figure C-7. Curves for 500, 1,000, and 2,000 foot KA-60 Camera altitudes on a 1:50,000 scale plot

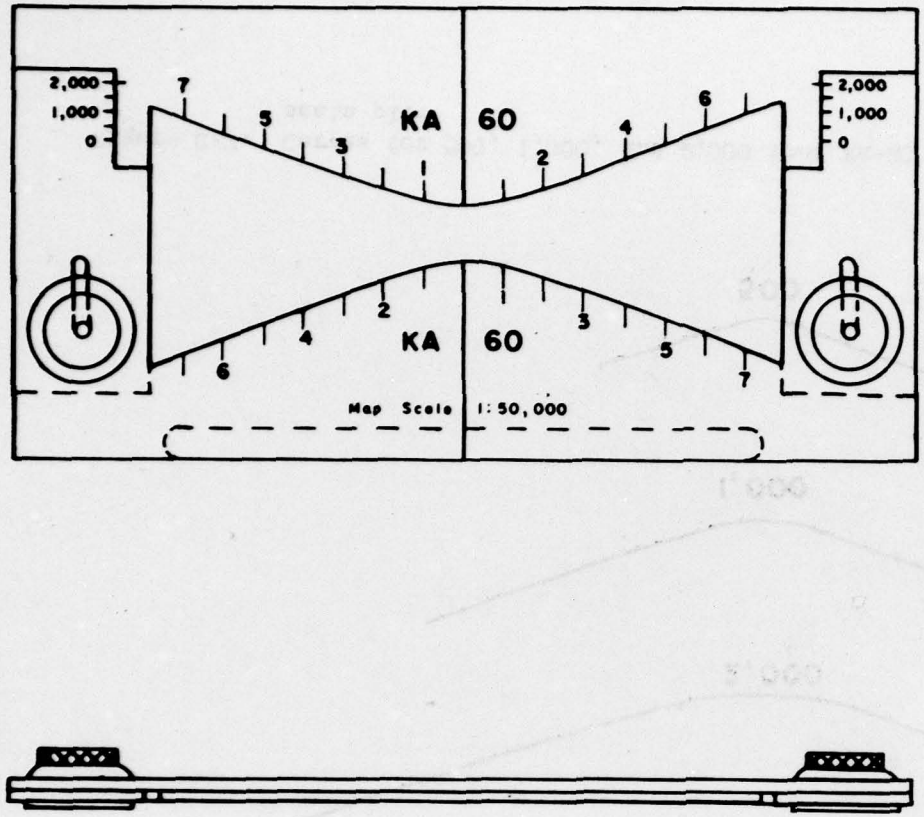


Figure C-8. Configuration of a plotting template for the KA-60 Camera System for use with 1:50,000 scale plots and camera altitudes up to 2,000 feet

After the template is properly positioned, the curves are drawn on the overlay out to the desired ground distance using the ground distance tic marks as guides. Since it is present plotting procedure to show oblique photographs which include the horizon as an open-ended figure ([ ), the curves for the KA-56 plot are drawn in a similar manner except the plot is double open-ended. The curves in the template have been extended far enough to include a ground distance from the nadir which exceeds the practical limit of tactical interpretability.

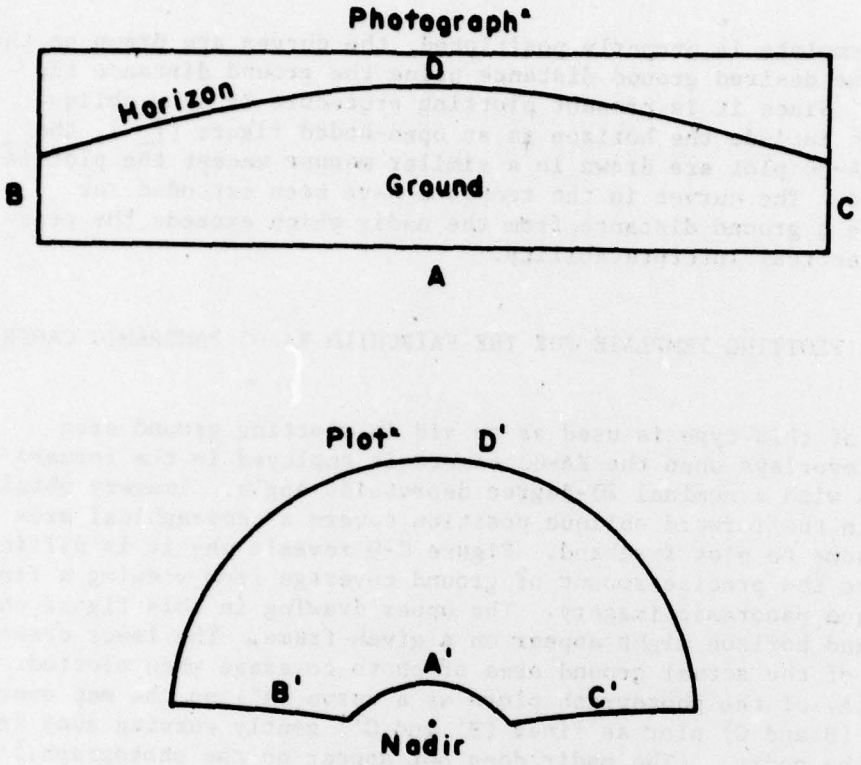
A NON-ADJUSTABLE PLOTTING TEMPLATE FOR THE FAIRCHILD KA-60 PANORAMIC CAMERA SYSTEM[8]

A template of this type is used as an aid in plotting ground area coverage on map overlays when the KA-60 camera is employed in the forward oblique position with a nominal 20-degree depression angle. Imagery obtained from the KA-60 in the forward oblique position covers a geographical area that is troublesome to plot freehand. Figure C-9 reveals why it is difficult to even visualize the precise amount of ground coverage from viewing a frame of forward oblique panoramic imagery. The upper drawing in this figure shows how the ground and horizon might appear on a given frame. The lower drawing shows the shape of the actual ground area of photo coverage when plotted. The lower edge (A) of the photograph plots as a curve (A') on the map overlay. The sides (B and C) plot as lines (B' and C') gently curving away from a point behind the nadir. (The nadir does not appear on the photograph.) The horizon (D) appears as a small segment of a circle, but the ground plot appears as a nearly complete semicircle (D') with the nadir at its center.

Each frame of imagery shows foreground detail which, although distorted, is relatively discernable. As with any oblique photography, detail becomes less distinguishable as ground distance from the camera increases. It would not be very meaningful to make plots that show area coverage to the horizon since, even at altitudes as low as 200 feet, the scale of objects on the horizon shown in the imagery would be beyond the practical limit of tactical interpretability. Besides, a plot to the horizon for most operational imagery of this type would extend beyond the limits of a single map sheet. The following schedule shows the scale of objects at the indicated lateral ground distances for several altitudes:

Altitude	Lateral Ground Distance	Scale
1,000'	10,000'	40,200
750'	7,500'	30,150
500'	5,000'	20,100
200'	2,000'	8,040

[8] See footnote 1 on page 41.



*Photograph and plot not to scale

Figure C-9. Graphic representation of a frame of KA-60 Forward Oblique Panoramic imagery and the geographical area of coverage on a map overlay.

The size and shape of map area coverage for any given altitude can be derived by mathematical computation. The measures needed for these computations include focal length, altitude, scan velocity rate, sensor platform velocity, variation of image motion compensation across the imagery, camera depression angle, and frame format dimensions. The camera manufacturer has developed a KA-60 Forward Oblique Panoramic Photography Coordinate Grid (20°-depression angle) imagery overlay for use in determining ground distances. The grid was used to avoid making a number of lengthy calculations to establish the size and shape of ground coverage. A series of curves was plotted to determine the ground area coverage for a number of altitudes. The curve for each altitude was based on the x-y coordinates of points along a line connecting the bottom two index marks and the left and right edges on the grid. The procedure was to read selected coordinate points in terms of representative ground distance in feet from the grid's vertical and horizontal center lines. These values were then multiplied by camera altitude in hundreds of feet and divided by the map scale (1:50,000), resulting in map distances in decimal equivalents of a foot.

The design of a plotting template for the KA-60 Panoramic Camera System used in the forward oblique position with a 20-degree depression angle is shown in Figure C-10. This design incorporates the altitudes and lateral ranges given in the above schedule.

With forward oblique panoramic imagery, the amount of imaged area covered varies considerably with the acquisition altitude. Altitude changes greatly affect the radii of the curves to be plotted; an infinite number of curves would therefore be required for precise plotting for all possible sensor altitudes. However, it is possible that templates designed for every 100-foot increment in altitude should prove operationally acceptable for plotting purposes.

To use this template, the area covered by the frame of imagery to be plotted is located on the appropriate map. If the frame of imagery contains a data block, the aircraft's true heading and altitude are determined; the curve that matches the altitude of the aircraft is then selected and the center line of the selected curve is oriented on the overlay coincident with the aircraft's true heading. If possible, an object is located on the map at or near the bottom edge of the imagery. Maintaining the azimuthal orientation, the template is shifted until the known object on the map is positioned in the template opening relative to the position of the object on the imagery, taking into account the distortion of the imaged area. In the event the true heading of the aircraft cannot be determined initially, then the template can be oriented using the relative positions of two or more imaged objects. Once this has been accomplished, the center line of the template will be aligned with the true heading of the aircraft and this information can be used in plotting other frames of the same run.

After the template is properly positioned, the curves are drawn on the overlay to the desired ground distance using the ground distance tic marks as guides. Since it is present plotting procedure to show oblique photographs which include the horizon as an open-ended figure (_/), the curves for the KA-60 Forward Oblique plot are drawn in a similar manner, except that the baseline consists of a curve and the ray counterparts are segments of a circle. The side curves in the template have been extended far enough to include a ground distance from the nadir which exceeds the practical limit of tactical interpretability.

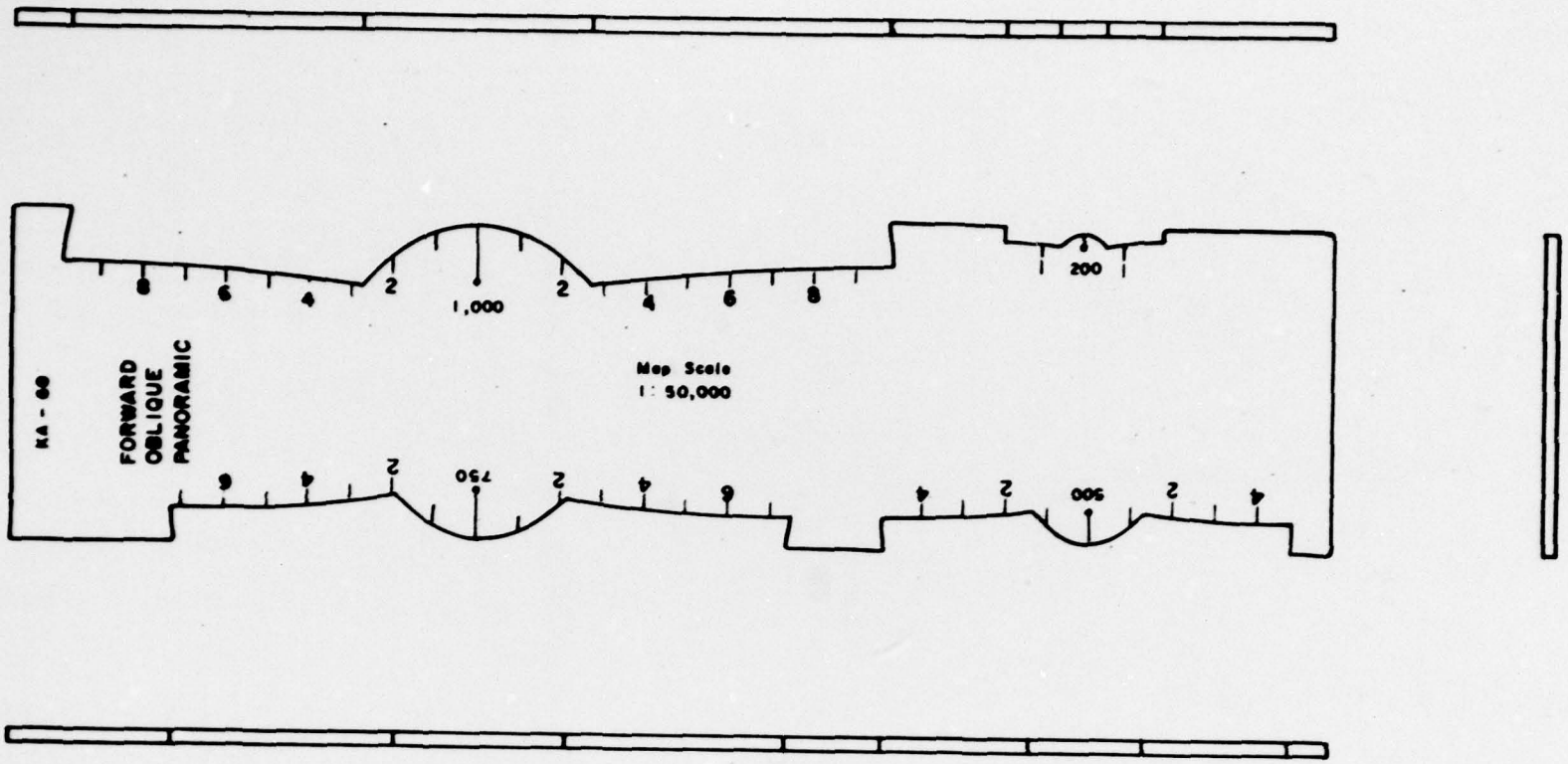


Figure C-10. Configuration of a plotting template for the KA-60 Camera System in the forward oblique position for use with 1:50,000 scale plots and camera altitudes of 200, 500, 750, and 1,000 feet

APPENDIX D. COMPARISON OF FREEHAND AND TEMPLATE-AIDED PLOTS OF KA-55 HI-PAN[7] AND KA-56 LOW-PAN[8] VERTICAL IMAGERY

PURPOSE

To determine the relative effectiveness of plotting KA-55 and KA-56 imagery freehand and template-aided.

PROCEDURE

Sixteen recent graduates from the U. S. Army Intelligence School at Fort Holabird, Maryland were given the task of plotting one frame of imagery freehand and another frame from a different camera system and geographical location, using specially designed plotting templates. Each image interpreter was assigned, at random, to one of four different conditions:

1. KA-55 freehand plot first, followed by KA-56 template-aided plot.
2. KA-55 template-aided plot first, followed by KA-56 freehand plot.
3. KA-56 freehand plot first, followed by KA-55 template-aided plot.
4. KA-56 template-aided plot first, followed by KA-55 freehand plot.

This balanced design offset the practice effect. Only one selected frame from each of the two sets of imagery was to be plotted. Each subject was allowed to examine the 10 frames preceding the selected frame in the same run so that he could establish the flight line and orientation of the imagery. Since the task of this exercise was the establishment of the plot for the eleventh frame, the experimenter explicitly pointed out the features of the first frame or two and how to determine the ground plot curve by locating landmarks on the periphery of the imagery. The image interpreters were also instructed how to set the plotting templates to the appropriate acquisition altitudes and how to orientate the center line of the template.

The plots were made on tracing paper map overlays. Imagery for the KA-55 Hi-Pan camera system was taken at 4,800 feet over South Vietnam; imagery for the KA-56 Low-Pan camera system was acquired at 4,000 feet over Fort Sill, Oklahoma. Each subject was asked to indicate the nadir position and camera center line heading for each plot.

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[7] See footnote on page 41.

[8] Idem.

SCORING

Time to make each plot was recorded to the nearest tenth of a minute.

A criterion plot for each camera system was established by the unanimous agreement of four experienced image interpreters. All these image interpreters are retired from the U. S. Army and all had had experience in this field ranging from 11 to 14 years. Each of the obtained plots was compared to the criterion plots in terms of distance in millimeters between the nadir locations and azimuthal rotation in degrees between the center line headings. A tabulation of these differences as well as the time to complete each plot are given in Table D-1.

RESULTS

The results (Table D-1) indicated that for the KA-55 imagery the freehand plots, on the average, took about twice as long as the template-aided plots (13.24 minutes versus 6.64 minutes). The mean nadir positions of the freehand plots showed closer agreement with the criterion nadir position (an average of 3.88 mm difference as opposed to 5.3 mm difference for the template nadir position). However, in the matter of azimuthal rotation, the template axis showed an average of only 3.50 degrees right as compared to 6.75 degrees right for the freehand orientation.

With respect to the KA-56 imagery, the time to plot was markedly in favor of the template approach. The mean time of 7.16 minutes for the template and 25.68 minutes for the freehand method showed the latter to take 3.59 times as long as the former. The mean excursions of the nadir positions in both methods from the criterion nadir position is very small--.625 mm for the template plots and 1.31 mm for the freehand plots. The average azimuthal rotation of the axes for both methods differed from the criterion axis by less than 2 degrees.

The sizes and shapes of the freehand plots varied considerably from a true plot of the area covered by the imagery. Some freehand plots were fairly accurate while others were quite anomalous. No attempt was made to quantify these differences.

CONCLUSION AND UTILIZATION

The use of specially designed plotting templates to delineate the area of coverage obtained from high and low panoramic imagery shows promise of reducing the time needed to make map overlays. Since the completion of this brief exercise in plotting, the plotting templates have been modified to include tic marks to indicate every 1,000 feet of ground distance on a 1:50,000 scale map. This convenience is expected to save additional time in establishing the lateral distance of the plots out to the practical limit of tactical interpretability of objects on the ground. In addition, a possible source of error is eliminated since these lateral distances will not have to be calculated for each plot.

Table D-1

COMPARISON OF RESULTS OBTAINED IN TEMPLATE-AIDED AND FREEHAND PLOTTING OF KA-55 AND KA-56 IMAGERY FOR 16 SUBJECTS

(BY PLOTTING TIME, NADIR DISTANCE, AND AZIMUTHAL ROTATION)

KA-55 IMAGERY

Template-Aided				Freehand			
Subject	Time (Min.)	Distance (mm)	Rotation (Degrees)	Subject	Time (Min.)	Distance (mm)	Rotation (Degrees)
1*	15.2	12.5	0	2	12.9	1.0	8 right
3	6.7	1.0	3 right	4*	17.7	1.0	8 right
5*	2.5	2.5	6 right	6	19.1	6.5	0
7	7.2	14.0	8 right	8*	15.1	5.5	16 right
9*	5.1	4.5	9 right	10	6.3	1.0	7 right
11	5.0	4.0	2 left	12*	13.5	5.0	8 right
13*	6.8	2.0	0	14	10.6	2.5	2 right
15	4.6	2.0	4 right	16*	10.7	8.5	5 right
Mean	6.64	5.30	3.5 right	Mean	13.24	3.88	6.75 right

KA-56 IMAGERY

Template-Aided				Freehand			
Subject	Time (Min.)	Distance (mm)	Rotation (Degrees)	Subject	Time (Min.)	Distance (mm)	Rotation (Degrees)
2*	14.0	0.0	1 right	1	25.4	0.0	0
4	7.6	0.0	0	3*	33.4	0.0	3 left
6*	6.9	1.5	2 left	5	22.2	1.0	0
8	7.5	1.0	8 left	7*	35.4	2.0	1 left
10*	3.6	1.0	2 left	9	33.9	1.5	5 left
12	6.5	1.0	2 left	11*	16.9	0.0	2 left
14*	3.7	.5	0 left	13	17.2	2.0	5 right
16	7.5	0.0	1 left	15*	21.0	4.0	5 left
Mean	7.16	.625	1.75 left	Mean	25.68	1.31	1.38 left

*Condition given first to each subject